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ERATOSTHENES NO. 4.

By WILLIAM H. PICKERING.

Introduction.

In the Harvard Annals **53**, 75 a detailed photographic study was made of this crater, twelve photographs being taken at an average interval of colongitude of 13°, or about one day. By means of them an endeavor was made to show all the changes that took place in this region during a lunation, that it was possible to detect by means of photography. This research was supplemented by a certain amount of visual investigation.

This past summer it was decided to carry out further this same idea, by making a complete visual study of some small selected area upon the Moon, and learning everything that happened upon it, as far as weather and modern instrumental outfits would permit, during a period of four months. The region selected is located on the southern wall of this same crater, Eratosthenes, and measures 29 x 37 miles. Its area is 1073 square miles, and it is therefore a little less than one-third the size of the Yellowstone National Park. This region was selected partly on account of my previous familiarity with it, partly because it is nearly central upon the Moon, and partly because it shows in close proximity four of the most interesting phenomena that occur there, namely:—the snow peaks, the clouds or fogs, the fields, and the runs and plats.

It is perhaps needless to state that the writer does not ignore the well known difficulty of the small amount of refraction of a star when occulted by the Moon, implying a very rarefied lunar atmosphere, to which he has given considerable attention in his earlier papers, nor the added difficulty caused by the high temperatures of the desert regions of the Moon found by recent investigators. He uses the terms "snow," "clouds," "vegetation," etc., because these are the terms in common usage, to represent the same phenomena when observed on Mars. It is perfectly obvious that terrestrial vegetation could not exist on the Moon, and probably not on Mars. But something does nevertheless undoubtedly exist on both of these bodies, which, while differing more or less from anything with which we are familiar, can be better described by the word "vegetation" than by any other in the English language.

Since even some prominent astronomers have recently suggested

that these markings are due to shadows and shadings, I will repeat that nothing of this sort is possible between full moon and the hour when the Sun crosses the meridian of the crater. It is geometrically impossible, as a very little thought should show them. Figure 1 was drawn on September 24, 1923, between 14^h and 17^h G.M.T., colongitude 88°. Full moon occurred the same night at 13^h. The Sun crossed the meridian of the crater the next night at 18^h.

Nevertheless, a dark gray field is shown upon this drawing, which is not visible, nor can its outline even be traced, earlier in the lunation. See Figure 2 of the same region. See also Eratosthenes No. 2, in POPULAR ASTRONOMY 1921, **29**, 404, Plates XVIII and XIX. Eighteen runs or canals can be counted in this figure, and seven plats or lakes, using the terms familiar on Mars. None of these markings therefore can be either shades or shadows, but must be areas that are at times very much darker than their surroundings. It may in general be noted that both runs and plats sometimes occupy depressions in the Moon's surface, but are again sometimes found, like the field above shown, on mountain ridges and slopes. When the fields develop they cover depressions and elevations alike, with a uniform covering.

Obviously the first thing to do in beginning our study was to prepare an accurate topographical map of the region. There are two methods of map making as applied to the Moon, either by distances or by position angles. The latter is the quicker and more accurate method, but at least one distance is required in order to provide a scale.

As we all know, it was formerly believed that the Moon was unchangeable, and this view is even now expressed in some of our recent text books. In mapping this region, three maps were found to be necessary, because the changes observed were so marked, that to plot all the detail seen during the lunation on one map would have ended in hopeless confusion. See Figures 2, 3, and 4. Strange as it may appear these three maps represent exactly the same region drawn only a few days apart. Even the snows on the central peaks shown at the bottom of the map have shifted, evaporated, and reformed. Several of the more prominent plats, including numbers 13, 27, and 36 can readily be identified on all three maps by means of their latitudes and longitudes. Other plats, like 5 and 21, have changed in size, shape or position, and still others, like 7 and 31, have either appeared or disappeared. The runs have nearly always changed their location and shape. The first map, Figure 2, which is the result of over a dozen drawings on as many different nights, in different months, represents all those formations which are visible at some time or another after one and through five days after sunrise on the crater. The second map, Figure 3, extends from five to nine days after sunrise, and the third, Figure 4, from nine until thirteen days after sunrise. More accurately speaking the first map extends from colongitude 25° to 75°, the second from 75° to 125°, and the third from 125° to 175°. The

Sun rises on the crater in the west at colongitude 11°, and sets in the east at colongitude 191°.

Comparing Figures 1 and 3 we shall see a general resemblance between them, yet several features appear on the latter that are not found on the former. These are markings which appeared on some of the other drawings, made either earlier or later in the lunation, but which were not visible on the night when Figure 1 was drawn. To express the matter more definitely we may say, that this region changes from one night to the next throughout the lunation, when near full as well as at other times, and that the three maps therefore do not represent its appearance accurately on any given dates, but each is simply a composite of the drawings made during the periods specified above, much as a map of Mars is a composite of the planet's appearance during the whole of one or more apparitions. On the other hand at successive lunations the same formations, with slight unpredictable modifications, appear on corresponding dates. Consequently from any detailed drawing of this region we could determine without difficulty the age of the Moon at which it was drawn.

We shall describe at length only one of these regularly occurring changes in the present paper. It is perhaps the most conspicuous one, and the one to which we have already called attention briefly in our second paper above mentioned, the change occurring in the run named Main. In that paper we included a drawing showing that Main changed its position angle in a marked manner, while another run, Cross, changed little if at all. That drawing was based wholly on my own measures. The present one, Figure 5, gives three series of measures by myself, indicated by circles, and marked 1, 2, and 3. Of these the last refers only to the northern portion of Main. The two remaining series indicated by crosses, and marked 4 and 5, are by Mr. Hamilton. All of the observations have been made since those recorded in the earlier paper, numbers 1 and 2 in November and December 1920, number 3 in November 1922, and numbers 4 and 5 in March and July of 1923. As in the earlier plot, the abscissas represent colongitudes, and the ordinates azimuths. These latter for the lower curve have been increased by 180°, as compared with the earlier plot, in order to make the curves relating to Main and those relating to Cross strictly comparable. The heavy vertical line indicates noon, or the summer solstice in the crater.

By examination of the maps we are now able to see exactly what takes place in the case of the Moon, because the maps were constructed entirely independently of the position angles used in constructing the curves. The names of both runs have been entered on all three maps in order to facilitate identification by the reader, which otherwise might be difficult. Early in the lunation (see Figure 2) Main is inclined at an azimuth of 45°. It is quite wide, about three-quarters of a mile, and exhibits a fairly uniform curvature, concave towards the north-west. When it first emerges from the shadow it is only 0″.5 in

width, but rapidly widens, and in a couple of days measures 0".7. When it widens it also becomes lighter. At its southern end it terminates in the large circular plat number **53**. As the lunation proceeds, the run straightens in its northern portion, but exhibits a very sharp curvature near the plat. This implies that the southern portion moves south-easterly, away from the rising Sun, while the northern portion changes little at first. This latter statement is confirmed by curve number 3 of Figure 5, whose azimuth remains nearly constant. Between 70° and 90° the curves become steeper. This is also well shown by the five curves in my earlier paper, and is apparently due to the continued motion south-eastward of the southern end of Main, while

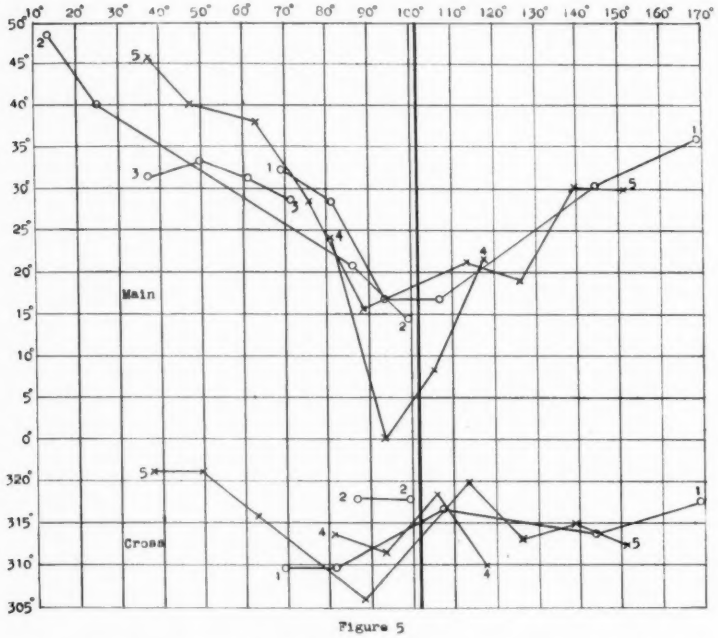

Figure 5

the middle portion has begun moving slightly towards the west. Compare the longitudes of Main in Figures 2 and 3. Main is now absolutely straight and less inclined to the meridian than before. The large plat at its southern end which was left behind by Main in its course, fades out of sight at about 80°, and does not reappear until 150°.

The southern portion of Main having now completed its easterly course, this is taken up by the northern portion, which slowly moves towards the setting sun, and up the inner face of the crater wall. This is best shown by means of the longitudes in Figures 3 and 4. It is also shown by the ordinates in Figure 5, as well as by the individual

PLATE IV

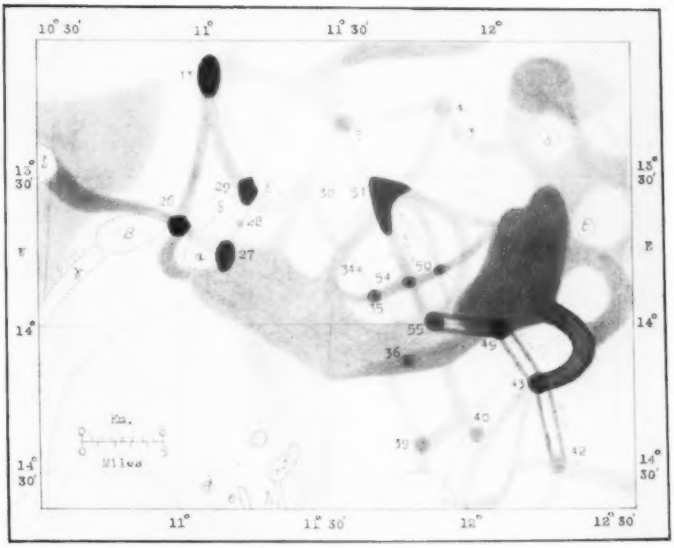

FIGURE 3, MAP B.

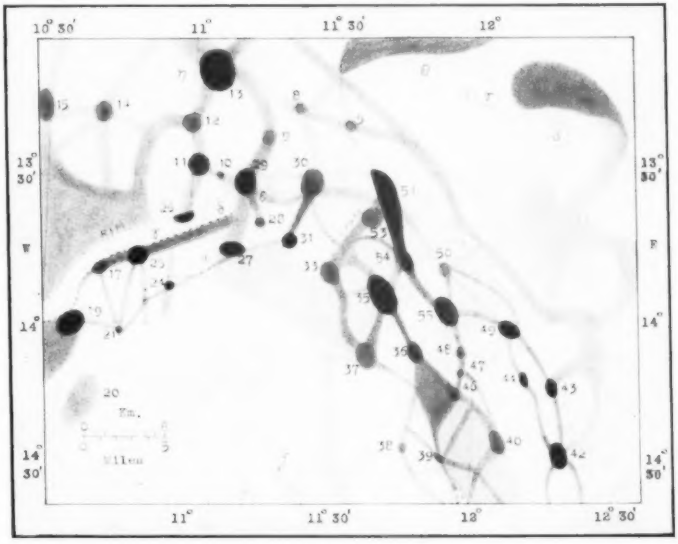

FIGURE 4, MAP C.

MAPS OF THE LUNAR CRATER ERATOSTHENES.

drawings of the region, which now represent the run as being clearly convex to the north-west, instead of concave, as in the earlier drawings. The measurements and later drawings also show that as the Sun sinks the run narrows and becomes darker. At colongitude 150° the width of its northern portion is only half a mile. From near the time of sunrise to noon the southern end of the run moves over a mile and a half to the south-east, at a mean rate of 60 feet per hour, while the middle of the run moves westerly towards the Sun, about one mile.

It is noticeable that in each case the distance travelled is greater than the width of the run. That a canal or run should visibly change its azimuth or direction appears in itself sufficiently remarkable, because whatever may be the explanation of the markings on Mars and the Moon, since they are, as we have seen, neither shade nor shadow, they must necessarily be either changeable surface discolorations of a mineral nature, or something growing, or else something moving over the surface,—mineral, vegetable, or animal. We can conceive of nothing else.

In this connection it may be of interest to make a brief comparison between the lunar runs and the Martian canals. In general the former may be said to be of about one two-hundredth the size of the latter, but being also at only one two-hundredth their distance, they can be studied equally well. We have moreover the great advantage in their case of knowing in general the third coordinate, that is to say of knowing whether they run up hill or down, and also whether they occupy depressions or elevations of the surface. To give an approximate idea of their relative angular size, we may say that the north and south dimension of the map is about 25″, so that if Mars were projected on it at a remote opposition, its diameter would be three-fifths the height of the map. At a very close opposition its diameter would equal the height. The lunar runs, while much narrower than those canals that we can observe on Mars, are quite as wide in proportion to their length, and are perhaps a little easier to see. The plats are larger in proportion, and are therefore much more conspicuous. They are about as numerous as the Martian lakes.

It should now be stated that the Eratosthenes region, while covering several thousand square miles of surface, is still only an oasis upon the Moon. It is separted by enormous desert tracts from other oases, such for instance as the Aristillus region. In this latter with its long divergent double canal, and its curious rectangular ladder-shaped formation, life seems to develop other forms. None of these oases occur nearer the poles than latitude 50°, but a considerable number are found within less than 20° of the equator. Our knowledge of the Eratosthenes region itself is by no means complete, perhaps it has only begun, since only a small portion of the oasis has already been carefully explored, but with the closing of this station by Harvard next September no further observations will be possible, and our future reports will have to be confined to an examination of those ob-

servations and records which we have already secured, or can secure before that date.

The Survey.

In planning our survey it will be readily seen from what we have already said, that our first and chief difficulty arose in selecting stations which would remain stationary, and which would be well distributed, and reasonably conspicuous throughout the lunation. The only points in fact on which we could surely rely are what we have called the "glows," and the bright craterlets. The former are small craterlets, usually less than a mile in diameter, which after being sufficiently warmed by the Sun emit a brilliant white circular glow due perhaps to fog, which surrounds them, and renders them very conspicuous until towards sunset. At this time the glow condenses and disappears, leaving only the minute original craterlet visible in its place. The best known of these glows is Linné. Fortunately two of them, described in my second paper on Eratosthenes lie just outside the crater rim. Their diameters range from 1″.0 to 1″.3, the craterlets themselves being far smaller. Their azimuth relative to the Moon's axis has been determined as 116°.3 ± 0°.4, and they have therefore served us to orient the three maps.

While no conspicuous glows occur in the region covered by the maps, there are three bright craterlets, each a little over a mile in diameter, located in the south-east quarter of the region, see Map C Figure 4, the two northern of which glow for a few days at a time, and the middle one of which can be followed throughout the lunation. This one, indicated on our maps by an *s*, has been selected to form one angle of our primary triangle, and the southernmost of the central peaks *c* one of the others. This latter is not so satisfactory as the craterlet, since the snow which makes it luminous shifts about it somewhat, and varies in the distance that it extends from the summit. The point is well located however, and very conspicuous throughout the lunation. We were not so fortunate in selecting the third one of our stations. No craterlet could be found near the upper left hand corner of our map, nothing but ill defined fogs and plats, many of which were of doubtful constancy. The best of the latter was finally selected and is indicated by the number **13**. On this primary triangle depends the whole of our survey.

The distances between these three stations expressed in miles, as measured by Mr. Hamilton with a filar micrometer are as follows: *c s* 26.5 ± 0.3, *s* **13** 21.6 ± 0.4, *c* **13** 22.8 ± 0.9. Six micrometer readings on three different nights were taken for each distance. A mile measured on the Moon is rather less than a second of arc, but on account of the lightness of our mounting, the occasional difficulty of seeing the markings *s* and **13**, and the rapid motion of the Moon, in both α and δ, greater accuracy was unattainable.

The azimuths of the sides of the triangle were measured with re-

spect to the lunar axis by means of four position-angles of each side, taken on five different nights, twenty in all. They are as follows: *c s* 135°.6 ± 1°.2, *s* **13** 258°.8 ± 2°,0, and *c* **13** 187°.0 ± 1°.**3**. It must be noted here that while the observed distances were corrected for the parallax of the Moon, neither the angles nor distances were corrected for its libration. The reason for this was that since Eratosthenes is located near the center of the disk, such a correction would not be very large, but would add greatly to the length of the computations, and would secure no adequate compensation. It was planned to determine the absolute position of every point upon the map within one mile. The relative positions, however, of one point with respect to another, were determined far more accurately by means of the drawings, and it is believed in the case of some of the more interesting ones, showing the greatest shifts of position, that their location on any given date with respect to their surroundings is known to within less than 1000 feet.

Taking the case of the distance *c s*, which would be the one between the primary points most affected by libration, its average deviation due to libration alone, using nights taken at random, would amount to ±0.4 miles. This distance was measured on the nights of September 21, 30, and October 1, and its average libration was 1°.1 towards the east, and 3°.8 towards the north. These two librations were so small that the result was practically *nil.*

It may be observed here that our problem is rather different from that usually presented to the land surveyor, and accordingly demands a somewhat different treatment. We shall therefore stop for a moment to consider how we should deal with our data. The data of the land surveyor generally consists of one distance and six azimuths. We on the other hand have three distances, and only three azimuths. The angles of our primary triangle therefore require no preliminary adjustment, but add up to exactly 180°. Giving equal weights to our distances and to our angles, and accepting at first the distance *c s* as measured, at 26.5 miles, we may solve the triangle as based on the three angles, and will find for *s* **13** 22.0, and for *c* **13** 23.4 miles. These last two are larger than the values obtained by the micrometer. Making the sum of the three distances equal in the two cases, and correcting accordingly, we obtain *c s* equals 26.1 miles, *s* **13** 21.7, and *c* **13** 23.1. Then taking the mean of these values and those determined by the micrometer, we obtain for our values *c s* 26.30 miles, *s* **13** 21.65, and *c* **13** 22.95. The average deviation of the means from these two values is 0.067 miles, or 350 feet, or 0″.06 at the mean distance of the Moon. From these distances we deduce the final angles *c* 51°.6, *s* 56°.2, and **13** 72°.2, corresponding to the azimuths *c s* 135°.6 taken as correct, *s* **13** 259°.4, and *c* **13** 187°.2. Owing to the fact that Eratosthenes lies 18° to the north-east of the center of the disk of the Moon at mean libration, all distances measured in this direction must be increased by about five per cent. This correction could of course

have been easily made on the map, but it seemed undesirable, since what we want to represent is not the actual shape of the markings, but rather the appearance of the surface as seen from the Earth.

The latitude and longitude of Eratosthenes is not given by Saunder, but Franz gives it as $\beta = +14° 29'.5$, $\lambda = 11° 20'.6$. These figures doubtless belong to the highest peak *f*, indicated by a small cross at the bottom of each map. This peak is really a small crater, central at the cross, and as we have seen, surrounded by snow. Its azimuth and distance from *c* were determined by means of the triangle *c f* **36**, a special micrometric measurement of the distance *c* **36** being made for the purpose, since the filar micrometer is not well suited to measuring very small planetary distances.

The location of each secondary station was determined by means of three azimuths, one being a side of the primary triangle. In each case the resulting triangle was solved, and the point located not by its azimuth directly, but by its distance from the two primary stations. While a little more troublesome, this method is probably more accurate, and involves fewer construction lines on the map than that of plotting the angles and taking intersections. The positions of the following secondary stations have been computed: *v*, 19, 26, 27, 35, 36, 41, 43, 45 and 51. The remaining portions of the map were located from the various drawings, of which we now have 34 made this past summer beside about a hundred general drawings of the crater made during the past twenty years.

Nomenclature.

The question of nomenclature for definite description next requires attention. While the runs and plats, as we have seen, occur only in rather small and comparatively isolated regions upon the Moon, separated by extensive desert tracts, yet their total number is so enormous that it would be impossible to find suitable and different names for all of them. The same names used in the Eratosthenes region could certainly without confusion be used in the regions belonging to other craters. On the present map 55 different plats have been identified, and a slight increase of optical power would doubtless reveal a number more. This map covers only a small portion of the Eratosthenes region. It is no easy matter to find a class of objects containing many distinct easily remembered names. Numbers cannot be remembered by most people. The Martian names are difficult for the beginner, and it did not seem wise to duplicate them. There are about 80 common names of flowers, and about 70 of trees. Animal names seemed inappropriate, and there are two few minerals and precious stones whose names are in common use.

We therefore decided to use the names of flowers for the plats, but to leave the runs or canals unnamed, excepting where names would add materially to the convenience of the description. It is then proposed to use common street names, such as might be found in any

large city. The two already employed and inserted on the map, Main and Cross, are commonly used in America. If all the plats were named, then any unnamed run might be designated by the names or numbers of its terminal plats, and if necessary by one or two others along its length. The obvious objection to this system is that it will be a little difficult for those selenographers unfamiliar with the English language. On the other hand most of the planetary astronomers who are interested in the Moon are either English or Americans, and these names will not be more difficult for others than many of the Martian names are for the English speaking nations. Moreover continental selenographers are certainly at liberty to apply whatever names they choose to the plats discovered and depicted by them. Thus we might have a French or Italian quarter of Eratosthenes.

In naming the plats, the whole region covered by the map has been divided into sections, and certain initials have been assigned to each of these. Thus all the plats lying outside the crater rim, on the right hand side of the map, begin with *A* or *B*. All those outside the rim on the left, begin with *C* and so on. The limits of the other sections will be determined by a comparison of Table I, which gives the name corresponding to the number of each plat, with the three maps. Following each name are given the letters indicating on which maps the plat is to be found. The regions temporarily occupied by the bright hazy objects, which we have called clouds, are indicated as on Mars by dotted lines, and are designated by Greek letters. Such letters are commonly used by selenographers to designate rills, but it is thought that no confusion is likely to arise in this connection. When a cloud occupies a region all detail beneath it, whether of runs or plats, is concealed. The bright craterlets, snow fields, and glows are indicated by small letter italics.

TABLE I.

List of Plats.

No.	Name	Maps	No.	Name	Maps	No.	Name	Maps
1	Anemone	A	19	Dahlia	A C	37	Magnolia	C
2	Arbutus	A	20	Forget-me-not	C	38	Mignonette	C
3	Aster	A B	21	Fuchsia	A C	39	Marigold	B C
4	Azalea	B	22	Foxglove	A	40	Nasturtium	B C
5	Bluebell	A B C	23	Gardenia	A	41	Oxalis	A
6	Buttercup	A	24	Gentian	A C	42	Peony	B C
7	Crocus	A	25	Gladiolus	A C	43	Pansy	B C
8	Camelia	A C	26	Geranium	A B C	44	Petunia	A C
9	Cardinal	A C	27	Goldenrod	A B C	45	Phlox	A
10	Calla	C	28	Harebell	B C	46	Primrose	A C
11	Carnation	A C	29	Iris	B C	47	Petraea	C
12	Chrysanthemum	C	30	Jasmine	A B C	48	Periwinkle	C
13	Columbine	A B C	31	Lotus	C	49	Poppy	A B C
14	Clover	C	32	Larkspur	A	50	Poinsettia	B C
15	Cowslip	C	33	Lilac	A B C	51	Rose	A B C
16	Daffodil	A	34	Lupine	B	52	Thistle	A
17	Daisy	A C	35	Lily	A B C	53	Tulip	A C
18	Dandelion	A	36	Laurel	A B C	54	Violet	B C
						55	Wisteria	B C

In a future paper it is hoped to describe in more detail the apparent movements of the clouds or fogs, the singular temporary duplication of a few of the runs, which is far more obvious than the similar phenomenon believed by many to exist on Mars, and the directions of motion, distances and rates of travel of some of the more conspicuous plats.

Mandeville, Jamaica, B. W. I.
December 4, 1923.

NOTES ON AURORAS AND MAGNETIC DISTURBANCES.

Posthumous Paper of the Late Professor C. C. Trowbridge.

Revised and Edited by MABEL WEIL.

EXPLANATORY NOTE:—*The following paper was found by the editor among some of the effects of the late Professor Trowbridge. The article was in very unfinished form, and apparently intended to be merely a rough draft. The editor has, therefore, been obliged to delete certain obscure portions, and to make various other revisions. The attempt has been made, however, to reduce to a minimum the changes in wording and in sequence of ideas. Statements added by the editor are enclosed in square brackets.*

An attempt will be made in the present paper to present and discuss various factors entering into an explanation of the aurora. The views of other investigators in this field will be set forth, together with the writer's ideas on this subject.

1. THEORIES REGARDING LUMINOSITY OF THE AURORA.

Several theories have been advanced to account for the excitation of luminosity of the aurora. They may be classified as the *(a)* electric, *(b)* magnetic, *(c)* solar corpuscular theories, and *(d)* gas phosphorescence.

a. Electrical Theory. Edlund[1], Rowland[2], Franklin[3], and others thought that the luminosity was produced by an electric discharge through rarefied air, the electricity being conveyed from the equator to the poles. In the main, the electric theories of the production of the auroras have been accepted by scientific men as giving the best explanation offered.

b. Magnetic Theories. Magnetic theories form a second class of explanations. In 1716 Halley, the famous astronomer, stated that the Aurora Borealis was due to self luminous "magnetic vapour." The theory took definite shape with Dalton (1793). Ferruginous dust, according to the magnetic theory, takes its direction under the influence of terrestrial magnetism, and serves as a conductor to silent discharges between the upper and lower strata of the atmosphere. "Dalton's ideas were revived by Biot (1820) who thought that the Aurora

Borealis might also be due to the presence in the air of ferruginous particles from volcanic eruptions. Von Baumhauer (Utrecht, 1840) also supported the same opinions, but attributed the ferruginous particles not to volcanic eruptions, but to the fall upon our globe of cosmic dust; the light of the auroras would, on this theory, be produced by the incandescence of this dust when it entered the atmosphere, as in the case of meteors and falling stars."

In support of the magnetic theory the fact has been mentioned that the aurora has been seen to be affected by the wind, thus acting like a cloud of meteoric dust[4]. Also on the soil of Arctic regions there exists a great quantity of ferruginous dust, and even masses of meteoric iron. A great rain of dust upon the earth has been observed during several auroras, notably in Padua in 1834, and throughout northern Italy at the time of the great aurora of 1872[5]. Nordenskiold examined Arctic snow, and found in it a sediment containing minute particles, globules of oxide and sulphide of iron, and others are said to have found meteoric sediment in the material dredged up from the bottom of the ocean[6]. The absence of meteoric sediment after an aurora, however, is not necessarily proof of the non-existence of such material during the aurora, for such sediment would in most cases be completely consumed without ash.

c. Solar Corpuscular Theories. Arrhenius[7], Birkeland[8], Norman[9], Vergard[10] and others recently have advocated a solar corpuscular theory of the aurora. Arrhenius's explanation is as follows:—It is known that from an incandescent metal or glowing piece of carbon "corpuscles" are projected. When corpuscles moving at a high rate pass through a gas, they make it lumnious. Birkeland has made numerous experiments with a "terrella" and together with Störmer has made elaborate calculations on the paths, deviations, etc., of particles projected from the sun's photosphere. Norman's theory differs from that of Arrhenius and Birkeland in that he held that the primary cause was Hertzian waves from the sun, which in turn gave rise to secondary cathode rays. Vergard considered the draperies, etc., of the auroras to be formed by alpha particles.

d. Gas Phosphorescence. Whatever the cause of the excitation may be, it is difficult to suppose that a cloud of dust would remain incandescent from heat for so long a time in the cold upper regions of the atmosphere. The writer would suggest that this incandescence is due to gas phosphorescence, and some of his experiments on the afterglow in nitrogen lend plausibility to this hypothesis.

2. Spectrum of the Aurora.

Various observers are not in entire agreement regarding the auroral spectrum lines excepting for the case of the strong green line. In the observations of various investigators, entirely different lines are discussed, so that the matter is still an unsettled one.

The work of Paulsen and Scheiner in this connection is described as follows:[11]

"In a preceding memoir, the author had noted the close agreement which exists between the spectrum of the aurora and that of the cathode rays in a spectrum tube containing nitrogen and oxygen. It is especially in the parts containing the most refrangible rays that the agreement is the most striking, not only with respect to wave length but also with respect to the distribution of the intensity of the rays. In the part of the spectrum of the cathode light, the rays which were photographed belong to the spectrum of nitrogen." Thus the spectrographic experiments made seem to show that the spectrum of the cathode light of nitrogen is found in the spectrum of the aurora, which is equally confirmed by the measurements of Scheiner.

The wave lengths found by Vogel, as quoted in Scheiner's "Astronomical Spectroscopy" are as follows:

4630-4695	broad band
5005	Bright line
5190	Bright line
5234	bright line
5390	faint line
5572	brightest line
6298	bright band

The values found by Sykora at Spitzbergen in 1899 have been compared by Baly with the krypton spectrum as follows:

Aurora (Sykora)	Krypton (Baly)
3912 strong	3913.01
4276 very strong	4274.15
4354	4355
4429	4431.85
4710	4710.68
5570 strong	5570.5

Many other lines were observed but they were too faint to be measured. The krypton lines were found in a vessel at low pressure with a jar and spark gap. The coincidence is far better than any other hitherto obtained and indicates the identity of the mysterious 5570 with krypton.

[Some measurements of the main aurora line and of other lines of the aurora spectrum have recently been made by Slipher[12], and the agreement with the krypton lines is not nearly so close as that idicated above. Slipher found that the principal aurora line has a wave length of 5578.05, or about seven units higher than the commonly accepted value. He used the solar spectrum as reference in his spectrographic work, and found that the solar line 5573.075 fell well to the violet side of this line. He also found a strong line at 3916 and one at 4277, as well as several weaker ones on his plates.]

3. Cause of Occurence of Auroras at High Latitudes.

The explanations on electric theories of the occurrence of auroras in high and not in low latitudes differ a little in detail, but the follow-

ing is typical. Rowland[2] held that the earth is electrified, and naturally that the electricity resides for the most part on the exterior of the atmosphere. The air currents thus carry the electricity toward the poles, where the air descends and leaves the charge; and the condensation so produced is finally relieved by discharge. The total effect would be thus to cause a difference of potential between the earth and the upper regions of the atmosphere both at the poles and at the equator.

At the poles the discharge of the aurora takes place in dry atmosphere. At the equator the electrostatic attraction of the earth for the upper atmospheric layers causes the atmosphere to be in unstable equilibrium. In some region of least resistance the upper atmosphere rushes toward the earth, moisture is condensed, a condensation thus formed on which electricity can collect; and so the whole forms a conducting system by which the electric potentials of the upper air and the earth become more nearly equal. This is the phenomenon known as a thunder storm.

Hence, were the earth electrified, the electricity would be carried to the higher latitudes by convection, would be discharged to the earth as an aurora, and passing back to the equator would get to the upper regions as a lightning discharge, once more to go on its unending cycle.

According to Edlund[13] the quantity of electricity accumulated in the atmosphere, and consequently its tension, increases with the latitude; at a given moment, then, the tension having become great, the electricity of the upper regions of the atmosphere will flow downwards towards the earth in currents which follow the direction of the dipping needle; this flow will occur by preference in regions where, as a consequence of temperature, humidity, etc., the conductivity of the air is greatest.

The magnetic theories are, in the main, in agreement with the electric theories with the exception that ferruginous dust was thought by Dalton and others to be the conductor of the silent discharges of electricity.

According to the corpuscular theories the explanation is essentially as follows:—The cathode rays emanating directly from the sun and most copiously from the sun-spots, on approaching the earth are directed into certain channels by the earth's magnetic field. Birkeland[14] has worked out this theory in considerable detail. His latest published work[15] shows that the difficulty is met in explaining *all* the auroral phenomena by the corpuscular theory.

4. Periodicity (Diurnal, Annual and Secular).

a. Diurnal Period. The aurora can only be seen when the sky is dark, therefore the law of its diurnal distribution and frequency cannot be determined. Lemstroem once found himself in the midst of an aurora, the spectroscope giving the characteristic yellowish-green line,

in all directions, although no distinct form of the aurora was seen in the heavens.

[Slipher in 1919, published some of his researches indicating the presence of a permanent aurora. His own account of this phenomenon follows in part: "In the past three and one-half years something like one hundred spectrograms have been made of the night sky, and every one of these has recorded the chief aurora line. Thus during this period of time auroral illumination of the sky has been found to be present on every night that an exposure has been made for detecting it. The spectrograph therefore gives direct evidence of the existence of a permanent aurora.

"The observations indicate an increase in the intensity of the aurora light as the zenith distance is increased. Also it is more intense in the sunrise and sunset parts of the sky than elsewhere."]

The hour of the maximum intensity appears to be clearly defined[16]; it occurs, as a rule, in the first half of the night, but later at higher latitudes. The tendency is for the aurora to follow local time and not to occur over a wide area at the same physical instant. These phenomena present some perplexing problems. Birkeland has worked out with great detail, an explanation based on the action of the sun which is very clearly suggested by the phenomena[17]. The purely magnetic and the electric theories offer no explanation for *this* diurnal change.

b. Annual Period. Angot[18] discusses the annual period of the aurora as follows:

The study of the annual period of the aurora presents a special difficulty on account of the great variability of the length of the day in just those regions where the aurora is the most frequent. For it is evident that, other things being equal, the apparent frequency of the aurora will be greater when the night is longer, and conversely. Yet this difficulty is not so great as it would appear at first, inasmuch as the auroras generally last a considerable time, so that the end of an aurora which has begun in the day time may be perceived after sunset, and especially because the maximum of the diurnal frequency of the aurora is at night.

"Mairan was the first to discover the law of the annual periodicity of the aurora borealis; he remarked that auroras are particularly frequent in France towards the months of April and October—that is to say, soon after the equinoxes—and that they are, on the contrary, rarer in January and especially in June. .....

"The two minima of winter and summer appear to be unequal; but this inequality is due, in part if not entirely, to the difference in length of the nights in the two seasons.

.....

"This law of periodicity appears to be modified in higher latitudes. The autumn maximum grows later and later, and that of the spring earlier, both thus approaching the winter solstice. This fact, noted first

by Lovering, has since been verified by numerous observers. It even happens, in sufficiently high latitudes, that the two maxima are fused in one, which falls near the winter solstice[18]."

c. Secular Period. "The idea of the periodicity in the returns of the aurora borealis occurred to Mairan. Although he had not determined the length of the period, he mentions all the occasions of the renewal of the aurora—that is to say, of the maxima of frequency of which he could find the trace as far back as classic times, by consulting historians and chroniclers. He even goes farther and asks whether it would not be possible to establish some analogy between the frequency, the cessation, and the return of the spots on the sun and the manifestations of the aurora borealis. 'This idea is encouraged,' he adds, 'by the fact that during these last five or six years, when the aurora borealis has been so frequent, so also have been the spots on the sun. It is known that at the beginning of the last century, after the invention of the telescope, the sun was hardly ever without spots; and there were at times such numbers of them that Scheiner said that he once counted as many as fifty. They afterwards became more rare, so that from the middle of the century until 1670—that is to say, for twenty years—only one or two were seen, and these only for a short time. Now, as we have seen, there was a great number of auroras at the beginning of the seventeenth century and till after 1621, after which date we hear no more of them till 1686.'

"After Mairan many authors have discussed this question, and proposed to explain the returns of the aurora by different periods. Hansteen believed that the period was ninety-five years on the average; Denison Olmsted gives a period of sixty-five years divided into two parts, the one of twenty-five years, during which the auroras are numerous, the other of forty years, during which the cause which produces the auroras is in repose. But none of these tentatives have led to any satisfactory results until there was a return to Mairan's idea of the relation of the spots on the sun and the aurora borealis.

d. Periodicity of Aurorae and Sun Spots. "It is known that the periodicity of the sun-spots, divined by Fabricius in 1610, was definitely proved by Schwabe in 1826, whose studies were amplified and confirmed by a great number of observers and men of science, among whom we may mention Warren de la Rue, Carrington, Secchi, Spoerer, and especially Rudolf Wolf, of Zurich. According to the latter, the spots of the sun observe a period of a little more than eleven years (eleven years and two months exactly) composed of two unequal parts; there are, on an average, six years between the maximum and the minimum which succeeds it, and five years between the latter and the next maximum. The period of increase is thus shorter than the period of decrease.

"These facts relating to the sun spots are perfectly certain at the present day. The periods are not all precisely equal, being sometimes

a little longer or shorter; but they never fail to manifest themselves, and there is always an enormous difference between the number of spots which correspond to a year of maximum and that of a year of minimum[19]."

Lockyer's conclusions regarding the aurora and sun spots are as follows: (1) "The seasonal variation in the frequency of the magnetic storms and auroras depends on the position of the sun's axis in relation to the earth. (2) The epochs of the greatest inclination of the sun's axis towards or away from the earth, or in other words the greatest exposure of the N. or S. solar polar regions to the earth during the year, correspond to those of greatest magnetic and auroral frequency. (3) The epochs (groups of years), when the solar polar regions are most disturbed, synchronize with those when the excess of the equinoctial over the solstitial frequency of magnetic storms is greatest."

In an article published in the *Proceedings of Royal Society*, volume 52, Lord Kelvin says:

"We have at the present two good and sure connexions between magnetic storms and other phenomena; the aurora above, and the earth currents below, are certainly in full working sympathy with magnetic storms."

However, the weight of opinion seems to be that there is a connection of auroras and sun spots. The question that remains unsettled is whether the auroras and magnetic storms are caused directly by sun spots and other action of the sun, or whether there is some indirect connection. [The discovery by Hale, that there are magnetic fields in the sun spots, as shown by the presence of the Zeeman effect in the sun spot spectra, may have some bearing here.] Although the electric theories do not explain directly the annual and diurnal variations of the aurora, they as well as the magnetic theories permit of an explanation due to the varying conductivity of the air as influenced by the action of the sun.

The puzzling part of the problem is to know just what the influence is, and why, as stated by Lockyer and others, the auroras occur more frequently at about eleven o'clock in the evening and later in higher latitudes and why they are most frequent at the equinoxes.

e. Periodicity in its Relation to the Various Theories. Two objections to the solar corpuscular ray theory might well be mentioned here: If the aurora borealis were produced by causes external to the earth it would present an apparent movement from east to west, but the inverse movement is the most frequent. Also, while the relation of the sun to diurnal and annual variation of frequency may be a disturbing element in the magnetic and electric theories, it is fatal to the solar corpuscular theory, for if the luminosity is caused by the direct effect of the particles from the sun moving at high velocity through the atmosphere, why is this luminosity produced where there are none of these particles arriving from the sun? Of course it is possible that

the earth does receive particles from the sun and that these particles do affect the conductivity of the atmosphere, etc., but surely the action is very indirect and just what effect they have, has not been determined. Although these particles may modify the conditions that are the primary cause of the aurora, it is in the electric theories or in a combination of the electric with other theories that the true explanation is to be sought.

5. Orientation of the Aurora with respect to the Magnetic Meridian.

The question of the orientation of the auroral streamers with respect to the magnetic meridian is a matter of considerable importance in any explanation of the aurora. This subject has been studied by many investigators some of whom reached the conclusion that the streamers are vertical, and others made the deduction that they coincided more or less closely with the magnetic meridan. The author's work (an account of which is to be published soon) furnishes experimental demonstration that the latter view is probably correct.

6. Height of the Aurora.

Professor Störmer[20] calculated from approximately 2400 observations that the aurora is most frequently observed at a height of from 90 to 140 kilometers. This zone is a little higher than the meteor train zone discovered by the author which is at a height of about 80 kilometers, and where the phenomena are also electrical in nature.

7. Relation of the Aurora to Terrestrial Magnetism.

Auroras which are seen over large portions of the globe seem to be always accompanied by magnetic disturbances. The more local auroras are not always thus accompanied, this being especially so in Greenland and the Arctic regions of North America[21]. At least one or two instances are on record when the magnetic disturbance preceded the appearance of the aurora. In connection with what has been said about the relation of auroras, these facts seem easily explainable, for a telluric current which generally accompanies an aurora would affect the compass needle, unless, as in the case of the smaller auroras, either the electricity accumulated over a small area, or its path or intensity was such that the needle was not affected. Moreover, whenever and wherever there is, for any reason, a telluric current flowing; magnetic needles will be affected. A second reason why, especially in the larger auroras, a disturbance of the magnetic needle occurs, is to be sought in the effect of the currents of electricity in the atmosphere upon the earth. This is more inert than the earth, and magnetism will result similar to that produced by allowing a current of electricity to flow through a coil around a soft iron core. Professor Silvanus Thompson[12] for more than twelve years held that the production of such currents as described in connection with the diurnal rotation of the earth,

affords the only rational means yet suggested (1901) for accounting for the growth of the earth's magnetism to its present state.

8. Conclusion.

It does not seem clear why there should be a flow of electricity from 55 to 80 miles above the surface of the earth at the poles. The thunder storms are produced within a mile of the surface of the earth usually, and more precise observations need to be made concerning the potentials of the earth and atmosphere in order to establish better the effect of difference of potential. Aside from this important criticism, the electric theory seems to account for all the phenomena with the exception of the effect of the sun spots and solar radiation; for it must be admitted that we receive particles from the sun, that modify the conditions of the production of the aurora. A modified theory admitting that these corpuscules, by ionizing the atmosphere, render it more conducting, would explain the results of Sir Norman Lockyer, and the observations of many others, and at the same time explain why the auroral rays usually follow the lines of force. On the other hand, a purely solar corpuscular ray theory is entirely inadequate. It seems possible that the presence of ferruginous matter also assists in the production of the aurora, for it is not possible to ignore the coincidences mentioned.

It seems to the writer that the supporters of the various theories have been working at cross-purposes. It may be, for instance, that auroras of one type have very little relative motion of their parts, and rather faint uniform discharge. Rays and draperies, etc., on the other hand, may be produced through air ionized by solar rays. When there are considerable changes in color and rapidity of motion there may be great changes in the intensity of the electricity. With the possible exception of the auroral phosphorescence being produced as in meteor trains, it seems probable that auroras are not produced unless there is an electric discharge as stated.

Department of Physics, Columbia University, Sept. 2, 1922.

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[1]Original work in Swedish. See description of work by Angot "The Aurora Borealis." A mathematical discussion by Edlund occurs in the Philosophical Magazine. Volume XXI, page 394. May, 1886

[2]H. A. Rowland, Philosophical Magazine, pages 102-106, July-December, 1879.

[3]Sylvanus P. Thompson, Magnetism and Electricity, page 326.

[4]Angot, page 66.

[5]Angot, page 156.

[6]Young's Astronomy, page 474, 1904 edition.

[7]Arrhenius, Original work in Swedish, see page 198 of J. J Thompson's Conduction of Electricity through Gases and Norwegian Aurora Polaris Expedition.

[8]Comptes Rendues, Tome 134, page 594, 1902; also in

[9]Journal de Physique, theorique et appliquée, Tome III, pages 281-319; 1904.

[10]Philosophical Magazine, Series 6, Volume 23, pages 211-237.

[11]Bulletin de la Société Astronomique de France, 1901; work of Paulsen and Scheiner.

[12]V. M. Slipher, Astrophysical Journal, Volume 49, pages 266-275, May, 1919.

[13]Angot, page 165.

[14]Norwegian Aurora Polaris Expedition, Volume I.
[15]Les Rayons Corpusculaires du Soleil qui penetrent dans l'atmosphere, Sont-ils Negatifs ou Positifs? Archives des sciences physiques et naturelles, Tome 41, per. 4, Number 1, January, 1916, pages 22-37 and Number 2, February, 1916, pages 109-124.
[16]Angot, page 80.
[17]Archives des sciences physiques et naturelles, Tome 32, per. 4, page 97, and Norwegian Aurora Polaris Expedition.
[18]Angot, page 87.
[19]Angot, page 94.
[20]Nature, Volume 97.
[21]Angot, pages 135 and 136.

LIGHT: AETHERIC vs. CORPUSCULAR.

By MALCOLM K. PARKHURST and WINTHROP PARKHURST.

The mathematical habit of erecting a mere abstract equation and expecting it to assume all those responsibilities which the allied phenomena of light, Hertzian waves, etc., call upon it to bear, may satisfy those who are concerned with this particular department of physics solely from a theoretical point of view. But to practical physicists such a facile substitution of symbols for facts is somewhat unsatisfactory, notwithstanding the physicist's debt to purely speculative thought. The growing confidence which the theories of aether had enjoyed since the decline of Newton's corpuscular or emission theory of light has therefore been a little shaken of late by demands for more empirical proofs. It is beginning to be felt that the more or less specific inability of physicists to make the aether accountable for things for which it needs to account, may constitute just grounds for suspecting that the explanation of certain of its phenomena may rest a little too lightly on facts.

While up to a short time ago scientists had definitely abandoned Newton's views regarding light*, they have more recently received a

*Newton's views regarding light were not, of course, restricted solely to a corpuscular hypothesis. Prior to the publication of his *Principia* he set forth, in a letter to Oldenburg, the possibility that there might be an "aetherial medium, much of the same constitution with air, but far rarer, subtiler, and more strongly elastic;" and this tenuous medium he thought might serve to explain not only light but also magnetic, gravitational and electrical phenomena. Two years later, in 1678, he was writing again, to Robert Boyle, of this possibility (see Brewster's *Memoirs of Sir Isaac Newton*, vol. I). Continual pondering on this problem, however, gradually led him to treat aether as a metaphysical postulate only, finding, as Maclaurin has observed, that "he was not able, from experiment and observation, to give a satisfactory account of this medium and the manner of its operation in producing the chief phenomena of nature." Attention is drawn to this detail because referring to the corpuscular theory of light as Newton's does not perhaps adequately advertise the fact that, as a physicist, Newton clung to it only after finding himself empirically unjustified in holding on to the more convenient postulate of an aether.

sharp rebuff in attempting to make aether behave as well ordered aether ought to behave. They hence are faced again with the necessity of considering whether aether really exists at all. And we find that a belief in this negative possibility holds true not only with specific reference to light, *i. e.*, electromagnetic waves: we are frequently referred to "magnetic fields," "fields of force," etc., in the same breath with which we are assured that aether has outlived its usefulness and is now simply a conventionalized symbol. But if not as fields of force in an all-pervading medium, as aether is imagined to be, then in what form are they to be considered physical entities? As strictly material objects? The truth of the matter is, that having outlawed a material conception of light, we promptly advanced to an aetherial one since it offered a readier explanation of its phenomena. But now, having advanced still further, we continue to explain those phenomena on a basis which, being none too convincingly substantiated by physics, is desperately relegated to the domain of mathematics.

It may be remembered that the era marking the decline of Newton's ideas had its inception about the time that his theory of light failed to account adequately for such things in the field of optics as aberration, refraction, and interference. Considering that an aetheric conception of the nature of electromagnetic propagation did quite logically account for the above-enumerated phenomena, it may perhaps appear strange that a sort of renaissance of the earlier speculations is in process of taking place. Moreover, any renewed interest in these prior theories cannot, it appears to us, be laid to any claims of their superiority or even of actual equality. A change of scientific front has been occasioned, rather, by the feeling that there is something inherently fallacious in our continual reference to a medium which we strictly know nothing about, and the existence of which we even are unable to prove—a medium assuming at will alternately contradictory qualities, and of such a subtle and confusing nature that men may well be excused for having believed it to be nothing but a cosmic fog emanating from the scientific imagination.

Without dogmatically taking either one side or the other in this controversy, we believe that we can nevertheless throw a little illumination on at least one of the several obscure features in the argument. To this end, we would refer the reader to the failure of the emission theory of light to account for the phenomenon known as interference.

It should be borne in mind that under the laws of this emission theory the source of any given light is considered to be an object emitting material particles or corpuscles of an almost infinitesimal size which, traveling at the prodigious speed of 186,000 miles a second, strike the eye wherein arises the sensation called light. Furthermore, it should be especially remembered that the various phases of this sensation, in terms of the *colours* of the visible spectrum, were explained in terms of the varied *size* of the corpuscles which the object was alleged to be emitting. To explain interference under the corpuscular theory, what

we primarily need to know is:—how can we, after taking a source of light which will be deliberately assumed to be emitting corpuscles of a uniform size—*i. e.*, monochromatic light—and after splitting up its path into two parts and letting these paths fall on a single field of vision, expect to obtain any such effect as interference? How, in other words, can matter added to matter actually produce nothing? In the corpuscular theory alone are we obliged to answer such a question, for in any theory of light based on the aetheric hypothesis we naturally are not confronted with this particular dilemma.

Now in the corpuscular theory, strangely enough, it has apparently remained an unquestioned truism that the minute particles emitted by the source radiate out not merely in all directions, but also in a steady and non-pulsating flow. But what, we may ask, is to prevent these corpuscles from being radiated in a fashion that is intermittent? Why, that is, can we not picture the phenomenon as "waves" which consist, not of a periodic displacement or oscillating charge, but of a movement whereby the corpuscles are simply thrown off periodically? Considering the source of light being, as it is, in violent molecular agitation, the affirmative answer to this question does not seem entirely or necessarily unsound. Nor would various sizes of corpuscles, granting this hypothesis, be needed to explain the various colours in the light; inasmuch as we here would have a wave, the specific length of which could determine the colours quite as easily as could aether waves in terms of the aetheric hypothesis. As a corollary to this proposition, we might likewise frame an explanation of how it is that when we combine two paths of monochromatic light the phenomenon of interference is produced. In much the same way that ether waves neutralize each other, a crest of corpuscles falling into the trough of the succeeding or preceding wave would create a uniform and steady stream; the pulsating effect known as light would hence no longer be sensible. Our eyes, in brief, would remain as unaffected by this steady pressure as our ears have been proved to be when subjected to a steady and uniform pressure of air. Finally, not the least interesting part of such a theory lies in the fact that, however fantastic it may appear, by a comparatively simple experiment the value of the hypothesis could be judged.

As the simplest approach to such an analysis, let us turn for aid to a Crookes radiometer. This little instrument, as is generally known, depends for its activity upon the expansion of the air next to the blackened surface of its vanes. An impetus is thereby given to these vanes in spite of the fact that the globe containing them is partially exhausted of its air. Now, according to Maxwell's theory regarding this phenomenon—a theory postulating the electromagnetic nature of light—the pressure of light is twice as great upon a polished as upon a blackened surface. The same fact holds true of any corpuscular theory. In approximate figures Maxwell showed that sunlight of normal intensity should exert a pressure of .4 milligrams on a blackened sur-

face and .8 milligrams on a polished one, when the area of each is a square metre. The soundness of Maxwell's belief was empirically confirmed by Lebedew. According to any theory of light the vanes of a radiometer would therefore revolve in a direction opposite to that ordinarily observed, provided the partial vacuum in the globe were made at least approximately complete. For proof of this latter belief we also are indebted to Lebedew. His experiment, which may not be familiar to the reader, was as follows:

Within a glass globe 10 cm. in diameter he suspended a thin glass rod by means of a fine glass filament. Two separate sets of vanes were supported by this rod, each set consisting of two platinum discs 5 mm. in diameter. These two sets were arranged one above the other and parallel as regards their axes. Of each set, one disc was blackened on both sides, while the other was similarly polished. Arranged thus, he had a central vertical supporting rod to which were affixed two cross arms to which in turn were attached the blackened and polished discs, the two blackened discs lying one above the other and the polished ones doing likewise. Light from an arc lamp, projected in a parallel line by one lens and focussed by a second lens, was then allowed to fall first on the blackened discs and then immediately afterward on the polished ones. For the purpose of reducing the radiometer action as much as possible, Lebedew exhausted the air in the globe to a point where the deflection was greater with the light incident on the polished vanes than on their blackened counterparts. The degree of exhaustion was sufficient to convince Lebedew that *light, incident on any surface, exerts a true pressure on that surface,* the pressure being twice as great on a reflecting surface as on a surface which has been blackened. Maxwell's prediction regarding the specific magnitude of these pressures was likewise confirmed at this time. This magnitude we have already referred to.

Having now reviewed the reactions of this radiometer, we shall briefly attempt to show that they may be strikingly applicable to the corpuscular problem under discussion.

To this end, let us first take a monochromatic light and with it produce interference fringes in the customary fashion. Instead of merely observing these fringes with the eye, however, let us avail ourselves of a photographic plate which we place in the field, thus obtaining a photographic copy of the lines which have been created. After developing and drying the plate we then return it again to the field as before, with the difference that we now have the plate mounted on a movable rack so that it may be moved laterally a minute distance by means of a fine worm screw. So equipped, we can obviously adjust the plate at pleasure in reference to the light, and can bring the light lines previously produced on the plate into coincidence with the dark lines of the interference rays, or vice versa. All visible light is thus prevented from passing through the plate. Finally, a modified form of the Crookes radiometer, according to the specifications of Lebedew

outlined above, is placed behind this plate; while between the plate and radiometer is placed a third lens which will focus on the vanes any light rays which might possibly be penetrating the former.

Now consider the circumstances which must arise from this arrangement of our simple paraphernalia. Interference, as understood under the electromagnetic theory of light, would be unable to produce any effect at all on the vanes of the radiometer, and this for the simple reason that our arrangement of the photographic plate absolutely prevents the passage through it of any visible light, the dark lines detected in the interference field, according to the electromagnetic theory, being powerless not only to excite the sensation called light, but to create any mechanical effect. This is true for the reason that we here recognize two opposing forces which optically neutralize each other. From the latter or mechanical disability, however, a corpuscular light would not necessarily suffer in the least. For although the dark lines are incapable of exciting the retina, a steady stream of corpuscles, as compared with their intermittent flow which alone could create the optical sensation of light, would nevertheless be able to exert a steady pressure on the vanes, and thus cause the radiometer to revolve.

The significance of such an experiment—an experiment easily conducted in any modern laboratory—is to be fully grasped only when it is realized that our foregoing proposed modification of the corpuscular theory is necessary in accounting for one of the outstanding objections to it—which is interference. And from the foregoing experiment we could empirically determine whether or not the phenomena of lgiht are best expressed in terms of Newton's or of Maxwell's theory.

As to practical considerations bearing on the conduct of such an experiment, it is evident that the source of the monochromatic light should be a powerful one. The field of interference also should be large. Only under these conditions, it need hardly be said, would the light focussed on the radiometer be powerful enough, in all likelihood, to excite in it any palpable motion.

AMERICAN ASTRONOMICAL SOCIETY.

REPORTS OF OBSERVATORIES
1922-1923

The Council has recently decided to include in the publications of the Society, annual reports of American observatories. Some of the larger institutions already print complete reports each year, but these are, as a rule, not available to many members of the Society, and it is thought that a useful purpose will be served by having short reports from the various observatories brought together in one publication. By action of the Society the word "American" is interpreted to include North and South America and adjacent islands. The reports which follow are arranged alphabetically according to the names of the observatories or the institutions with which they are connected. To conform with the fiscal year of nearly every institution concerned, the reports, unless otherwise noted, cover the twelve months ending June 30, 1923.

ALLEGHENY OBSERVATORY
UNIVERSITY OF PITTSBURGH
PITTSBURGH, PENNSYLVANIA

HEBER D. CURTIS, Director.
FRANK C. JORDAN, Astronomer and Assistant Director.
KEIVIN BURNS, Astronomer.
ZACCHEUS DANIEL, Assistant Astronomer.
BERTHA GRIER, Computer.
W. R. LUDEWIG, Demonstrator, in charge of Frick Public Evening Service.

The Observatory has had an average observing year; 2,921 plates were taken with the Thaw photographic refractor, bringing the total for this instrument up to 30,682 plates. About four-fifths of these are parallax plates, and the balance are on Mr. Jordan's extensive extra-focal photometric program. The total of published parallaxes has been brought up to 642, with about one hundred awaiting publication. Every effort is being made in the parallax program to bring the average probable error down to 0".005 by setting a higher limit as to number and quality of plates required for a determination, and satisfactory progress is being made in this direction.

Mr. Jordan's extensive photometric program comprises at present about 175 variables of all types; the internal probable error of the determinations is about 0.01 magnitude.

A program of precise determination of solar wave-lengths has been initiated by Mr. Burns, with the co-operation of Dr. Meggers, of the

Bureau of Standards, and financed in part by grants from the Bache Fund of the National Academy of Sciences. The method employs an interferometer in combination with a powerful grating spectrograph; étalon separations as large as 10 mm have been used with success, giving an interference order of more than 50,000, and an accuracy of one part in five million is easily secured. For this investigation, the Porter spectrograph, formerly mounted vertically, has been mounted horizontally on concrete piers in a basement room, and sunlight is sent down to it from a mirror on the polar axis of the Keeler reflector; a considerable amount of auxiliary apparatus has been constructed. The remounted instrument apparently satisfies the most extreme requirements as to rigidity and permanency of adjustment. In addition to arc comparisons on the plates of the main instrument (a vacuum arc is being constructed), Mr. Burns takes simultaneous neon grating-interferometer comparison plates in the third order of the same grating. A considerable number of plates of great excellence have been secured, and results of interest and value are confidently expected from this program, which will be continued for several years at least.

The Frick Public Evening Service continues to be greatly appreciated by the public; 6,598 visitors were entertained during the year at the 13-inch telescope or in the lecture room of the Observatory.

STUDENTS' OBSERVATORY

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

A. O. LEUSCHNER, Director and Professor of Astronomy.
R. T. CRAWFORD, Professor of Astronomy.
STURLA EINARSSON, Associate Professor of Practical Astronomy.
W. F. MEYER, Assistant Professor of Astrophysics.
C. D. SHANE, Instructor in Mathematics and Astronomy.

Two new temporary buildings comprising a seminar room, a class room for section meetings, three offices and a shelter for the transit instrument of the Lick Observatory have been erected during the year.

Mr. Crawford has carried forward his investigation of the motion of comets 1919*d* (Finlay-Sasaki), 1921*b* (Pons-Winnecke) to provide reliable predictions for their next returns in 1926 and 1927 respectively, and jointly with Mr. Einarsson, of 1922*b* (Skjellerup) to settle the question of possible identity with comet 1902*c* (Grigg).

Mr. Einarsson has undertaken the preparation of a table for the determination of line of position at sea and azimuth on land, and of a table of altitudes and azimuths of the sun for the latitude of Berkeley, the latter for checking the work of engineering students, of a catalogue of comet orbits from 1907 to 1923, with Howard Kaster, teaching fellow in astronomy, and further investigation of the orbits of the asteroids (588) Achilles and (624) Hector of the Trojan group.

Mr. Meyer has completed a research survey of comet 1919*c* (Metcalf) and the final determination of its orbit. With Mr. J. A. Pearce, fellow in the Lick Observatory, he has made plans, in affiliation with the Crocker eclipse expedition of the Lick Observatory to Ensenada, Mexico, to investigate the existence of polarized light in the solar corona.

At the request of the Yerkes Observatory the computation of the orbits of two lost asteroids originally discovered at Williams Bay in November was undertaken, for the first by Mr. Einarsson, and for both by Mr. Shane and Mr. Pearce. After rediscovery on the basis of the predictions, Mr. and Mrs. Shane have also completed a second orbit of one of the objects.

Mr. Leuschner, assisted by Mr. H. Thiele, research associate, formerly assistant astronomer in the Lick Observatory, has continued his investigations of the perturbations of minor planets with the aid of a university research grant. The results of the research surveys last year by the National Research Council, and of the critical survey of the various theories proposed for the determination of perturbations, have been applied with success to the determination of the motion of selected planets for which so far, in spite of extended researches, no satisfactory representation of the observations has been attained. The latest case just completed is that of the planet (94) Aurora, for which the tables give an eminently satisfactory representation of observations from 1867 to 1922 on the basis of an orbit derived from observations made in the years 1867-1873, and of the revised tables for the Hecuba group.

CINCINNATI OBSERVATORY

UNIVERSITY OF CINCINNATI
CINCINNATI, OHIO

J. G. PORTER, Director and Professor.
E. I. YOWELL, Associate Professor.
ELLIOTT SMITH, Assistant Professor.

The sixteen-inch equatorial, in charge of Mr. Yowell, has been employed mainly in making micrometrical measures of proper-motion stars too faint to be observed with the meridian circle. Occasional observations of comets, planets and occultations were also made.

Mr. Smith with the five-inch meridian circle has continued the observation of proper-motion stars. A few others have been included by request. Accurate time is furnished by the Observatory to many institutions and business houses in Cincinnati.

The Mitchel Observatory, in which is mounted the old Mitchel telescope, is used principally for the entertainment of the public. Many school classes from the city and neighboring places avail themselves of this privilege.

As the Observatory constitutes the astronomical department of the

University of Cincinnati, a part of the director's time is given to instruction.

DOMINION OBSERVATORY
OTTAWA, ONTARIO

OTTO KLOTZ, Director; R. MELDRUM STEWART, Assistant Director; R. E. DE LURY, Research Astronomer; C. C. SMITH, D. B. NUGENT, R. J. MCDIARMID, R. M. MOTHERWELL, F. HENROTEAU, Astronomers; E. A. HODGSON, Seismologist; C. A. FRENCH, Magnetician; A. H. MILLER, Gravity Specialist; W. C. JAQUES, E. C. ARBOGAST, Computers; W. S. MCCLENAHAN, J. P. HENDERSON, A. H. SWINBURN, W. W. DONSEE, R. G. Madill, J. L. O'CONNOR, J. F. FREDETTE, R. CALLANDER, Assistants.

Meridian Work and Time Service. Meridian circle observations have been carried on for a number of years on a programme of stars specially selected for use in latitude observations throughout Canada. This programme of observations has just been completed, and preparations are under way for entering on a new programme.

Field observations for latitude and longitude were made during 1922 at four stations in the Mackenzie river basin. The longitudes were determined by wireless telegraphy, time signals from various stations being received simultaneously in the field and at Ottawa.

A somewhat extensive time service, comprising about six hundred clocks, is maintained in the principal Government buildings. The wireless time signals from Annapolis and Lafayette are received regularly for comparison with Ottawa observations in connection with the international scheme of B. I. H. The primary clock system consists of two Riefler sidereal clocks in hermetically sealed cases, mounted in a constant temperature room.

Astrophysics. The 15-inch equatorial has been used in the determination of the radial velocities of stars, principally of the β Canis Majoris type, characterized by rapid short-period oscillations of radial velocity superimposed on oscillations with periods of the order of a month. Quite a large number of direct photographs, made with a small camera attached to the equatorial, has been accumulated. These are being studied with a view to the determination of photographic light-curves of variable stars. It is hoped, by the simultaneous study of light-curves and radial velocities, to throw light on the relations between the different types of short-period variables, including the Cepheids.

Solar Physics. The programme in solar spectroscopy includes the investigation of solar rotation, solar distance, sunspots, wave-lengths and the interpretation of their variations over the solar disc (convection, pressure, Einstein effect, etc.). Some preliminary work has been done in an effort to secure simultaneous observations of standard arcs, arcs in partial vacuum and five points along the solar axis—nine strips in all. The past year was decidedly poor for solar observations,

on account of smoke, haze and clouds. A new double comparator for measuring solar spectra has been completed.

Seismology. The equipment includes two Bosch photographic horizontal seismographs, a vertical instrument of the Wiechert type, two Milne-Shaw horizontal seismographs of the latest type and a deformation instrument. The three latter are mounted in a specially constructed underground vault. One of the Milne-Shaw instruments will be mounted to allow rotation into any desired azimuth without change of constants. Two hundred and eight earthquakes were recorded during the year and were reported to a mailing list of two hundred and thirty observatories.

Terrestrial Magnetism. Two parties were engaged in magnetic field work during the summers of 1922 and 1923 in northwestern Canada. In 1922 seventy-three stations were occupied, of which eight were re-locations of former stations for the determination of secular variation.

Gravity. Gravity observations with a set of pendulums of the Mendenhall type, which had been suspended during the war, have been resumed. A gravity observer accompanied the longitude party in the Mackenzie basin. A total of nine stations have now been occupied in this region, the most northerly of which is within the Arctic circle. The rates of the chronometers used were obtained from the same wireless signals used in the longitude work.

DOMINION ASTROPHYSICAL OBSERVATORY

VICTORIA, BRITISH COLUMBIA

J. S. PLASKETT, Director.
W. E. HARPER, Research Astronomer.
R. K. YOUNG, Astronomer.
H. H. PLASKETT, Astronomer.
MISS H. R. KEAY, Secretary.
T. T. HUTCHISON, Night Assistant.

Observing. The observing weather during the year under review has been poorer than normal. The dome was opened on 194 nights and 1360 spectra obtained. On 127 nights it was clear throughout and 5 or more spectra were made, while on 67 nights it was partially cloudy and less than 5 spectra were obtained.

Observing Programmes. As previously, practically the whole time of the telescope, except two hours every Saturday night when it is given for observation to the public, has been devoted to photographing stellar and nebular spectra. The director has given practically all his observing time to obtaining spectra of all O-type stars within reach at Victoria. Mr. Harper and Mr. Young have obtained spectrograms of stars of known parallax and of other suitable stars in continuation of their programme of absolute magnitudes undertaken the previous year.

H. H. Plaskett made observations of some O-type stars and nebulae but has principally observed from the general programme of H.R. stars. Messrs. J. W. Campbell and S. L. Boothroyd made some observations on spectroscopic binaries and on the general programme during the summer vacation of 1922, when they spent three months at the observatory as research assistants.

Researches. The director has been occupied almost entirely in the observation, measurement and reduction of spectra of the O-type stars both absorbing and emission and there still remains considerable work before completion. The space velocities of the O-type stars appear to be considerably higher than the B's, their mean parallaxes smaller and their absolute magnitudes brighter. An interesting side result is the behaviour of the stationary calcium H and K invariably present in these stars, generally differing greatly in velocity from the star lines and apparently only explainable by the presence of a widely diffused tenuous cloud. In addition the orbits of two O-type binaries have been completed. Messrs. Harper and Young have made good progress in their investigation of absolute magnitudes by the spectroscopic method and are obtaining results for about 1100 stars. Several new pairs of lines showing the absolute magnitude effect have been discovered, the curves are much smoother and some of the difficulties and anomalies of earlier work have been removed. In addition Mr. Harper has obtained the radial velocities of 125 stars and completed three binary orbits. Mr. Young assisted Mr. Chant in obtaining plates for the Einstein displacement at the Australian eclipse. These plates were measured both by Harper and Young and were reduced and discussed by Mr. Young with values for the deflection confirmatory of the relativity theory and agreeing with the 1919 results. One binary orbit has also been completed by Mr. Young. Mr. H. H. Plaskett has been occupied the major part of the year on the application of the wedge method to astronomcial spectrophotometry. He proved the accuracy of the method by its application to laboratory sources, carried through a very careful calibration of the neutral tint wedge used, determined the temperature of the intermediate standard of the carbon arc and applied the method to the sun and several typical stars. The results for the sun were especially interesting and valuable as by care in using regions for measurement relatively free from absorption lines, the intensity distribution in the solar spectrum agreed much more closely with black body radiation and gave a temperature somewhat higher than previous observations. The preliminary results from the stars were also in general agreement with those obtained from ionization and other methods. The method shows great promise and will be further applied.

Publications. There have appeared during the year as *Publications of the Dominion Astrophysical Observatory*, Vol. I, No. 30, which completed the volume and Vol. II, Nos. 3 to 9 inclusive, while other numbers are in press and preparation.

GOODSELL OBSERVATORY
CARLETON COLLEGE
NORTHFIELD, MINNESOTA

HERBERT C. WILSON, Director, and Professor of Mathematics and Astronomy.
CURVIN H. GINGRICH, Professor of Mathematics and Astronomy.
EDWARD A. FATH, Professor of Mathematics and Astronomy.

The time of the observers is largely taken up with teaching duties in the college and editorial work on the magazine *Popular Astronomy*.

Mr. Fath has devoted much of his spare time to the designing and construction of a photo-electric photometer to be attached to the 16-inch refractor. It is hoped to have this apparatus in working order during the coming year.

Messrs. Wilson and Gingrich have continued the series of photographs of asteroids for determining their positions and brightness. During the year fifty-six photographs were taken and forty-one plates have been measured and the reductions are well advanced.

Miss Anne S. Young, director of the Mount Holyoke Observatory, is co-operating with us in this work and has measured fifteen plates during the year.

The trustees of the Watson Fund of the National Academy of Sciences have made, as for several years past, a grant of $300 to aid in measurement and reduction of the asteroid photographs.

Publication No. 10 of the Observatory is in preparation for printing and will probably be issued early in 1924. It will contain the results obtained from the asteroid photographs taken in 1920-23.

Time signals have been sent out daily by wire to the Great Northern, Northern Pacific and Sault Ste. Marie railroads. Our time is checked up occasionally by the wireless signals from Arlington and Annapolis, the agreement being usually very close.

UNIVERSITY OF ILLINOIS OBSERVATORY
URBANA, ILLINOIS

ROBERT H. BAKER, Director and Professor, from September 1, 1923.
CHARLES CLAYTON WYLIE, Associate, in charge from September 1, 1922, to August 31, 1923.

The investigations of three stars on the program of the photo-electric photometer were completed and published. Mr. Wylie's contributions, *Astrophysical Journal* **56**, 217 and 232, are entitled: "The Cepheid Variable η Aquilae" and "The Eclipsing Binary σ Aquilae;" Mr. Stebbins' paper in *Astrophysical Journal* **57**, 1, discusses "The Ellipsoidal Variable *b* Persei." The use of the sliding-prism polarizing photometer on the 12-inch refractor was resumed by Mr. Wylie for the systematic study of certain variable stars, among them the

eclipsing variable WW Aurigae. Preliminary values of the absolute elements of the orbit from his completed light-curve and Joy's spectroscopic orbits of the two components appear in *Popular Astronomy*, **31**, 93. A study of δ Cephei was undertaken with the purpose of detecting any change in the range of light variation since Stebbins' observations of 1906-7 with the same equipment. No certain change is indicated by a preliminary discussion of the observations.

LICK OBSERVATORY

UNIVERSITY OF CALIFORNIA
MOUNT HAMILTON, CALIFORNIA

W. W. CAMPBELL, President of the University and Director of the Lick Observatory; R. G. AITKEN, Associate Director and Astronomer; R. H. TUCKER, W. H. WRIGHT, J. H. MOORE, Astronomers; R. TRUMPLER, F. J. NEUBAUER, Assistant Astronomers; E. A. KHOLODOVSKY, Assistant; J. DAMEN STERCK, Dome Assistant; R. H. BAKER, Martin Kellogg Fellow; J. A. PEARCE, T. S. JACOBSEN, E. F. CARPENTER, University Fellows; CARL BERGMAN, Photographer; MISS E. M. THOMAS, Secretary; MISS LONA CRANE, Library Assistant; G. F. PADDOCK, Acting Astronomer, is in charge of the Chile Branch of the Observatory, at Santiago, Chile.

The two outstanding events in the history of the Lick Observatory for the year ending June 30, 1923 are: (1) the very successful observations secured at the total eclipse of the sun on September 21, 1922, at Wallal, Australia, and (2) the election of Mr. Campbell to the office of president of the University of California.

The personnel of the eclipse expedition, which was made possible by the generosity of Regent W. H. Crocker, consisted of Mr. and Mrs. Campbell, Mr. Moore, and Mr. Trumpler. In addition to the continuation and extension of the program of photographic and spectrographic studies of the corona carried out at earlier eclipses, the expedition had for its objective the measurement of the deflection of star light in passing through the sun's gravitational field. Two twin cameras, of 15 feet and 5 feet focal length respectively, equipped with lenses specially figured to give good images over a photographic plate 17 inches square, were employed for this purpose. The mountings were designed by Mr. Campbell and constructed in the observatory shops. Measurement of four photographs taken with 15-foot camera by Messrs. Campbell and Trumpler gave $1''.72 \pm 0''.11$ for the deflection at the sun's limb. Einstein's predicted value was $1''.745$. Mr. Trumpler is now engaged upon the measures of the 5-foot plates.

Immediately upon his return from Australia, in November, 1922, Mr. Campbell was offered the position of president of the University, and in January accepted the offer, the acceptance to date from July 1, 1923, the understanding being that he would retain his title as director of the Lick Observatory, and would continue to be responsible for

its general policy, an associate director being appointed to take active charge of the work at Mt. Hamilton. The resulting organization of the staff as of date July 1, 1923, is as given at the beginning of this report.

Three modern cottages were completed and the re-modeling of the director's house was begun during the year. The building program thus initiated is expected to continue for several years, until the accommodations urgently needed on Mt. Hamilton have been provided. The installation of a new light and power line was authorized by the regents of the University in the spring of 1923 and it is expected that this will be completed by January 1, 1924. The chief additions to the instrumental equipment during the year, in addition to the Einstein cameras already mentioned, consist of an objective wire grating for the Crossley Reflector and an interferometer of the Anderson type for use with the 36-inch refractor.

The observing conditions in the autumn months of 1922 were of average quality, but in the following spring months they were decidedly below average. In the main, the observational work was confined to the continuation of extensive programs and the discussions of the results obtained are not yet complete. With the 36-inch refractor approximately 500 spectrograms were secured during the year, in continuation of the program of radial velocity determinations of stars and nebulae, Messrs. Moore, Neubauer, Pearce, Jacobsen, and Miss Powell being the observers. Mr. Aitken practically completed his program of remeasuring the double stars of his own discovery, continued the observation of a selected list of binary stars in rapid orbital motion, and made tests of the interferometer. Mr. Luyten, (Martin Kellogg fellow until Jan. 1, 1923) observed the spectra of a selected list of faint stars of large proper motion.

The Crossley Reflector was utilized chiefly by Messrs. Pearce and Jacobsen in the study of the ultra-violet spectra of the brighter class B stars and Cepheid variables, but, in addition photographs of the planets, the moon and nebulae were secured and Mr. Luyten also made satisfactory tests of the wire grating mentioned above.

With the meridian circle Mr. Tucker, after completing the program undertaken in 1921 to afford a rigorous test of a suspected diurnal variation in the clock rate, carried out a program of the observation of 240 standard stars selected chiefly to afford material for a check on the latitude of the station.

The photo-electric photometer attached to the 12-inch refractor was used throughout the year by Mr. Baker, with assistance from Miss Margaret Powell, University fellow, and Miss Mary Howe, assistant, in studies of the light variation of u Herculis, 12 Lacertae, Polaris, Algol, and other stars.

While Mr. Tucker finds no evidence for a periodic variation in the clock rate, his thorough review of all transits of standard stars observed here since 1893 does reveal systematic differences between the

azimuths determined from mire readings and those derived from the transits of circumpolar stars. He also finds indications of differences in the systematic errors in the star places in the odd and even hours of right ascension. Both sets of errors contribute to the observed excess in the *computed* clock rate during the night hours.

Mr. Wright has continued his investigations of the spectra of the novae. The positions of the principal bands in the lower or visual spectrum have been determined and the important part played by the element nitrogen in that region of the spectrum has been established. Consideration has also been given to the enhanced or ionized spectra which are of such importance in relation to the novae and related objects. During the year he published a brief description of the continuous radiation found in novae and planetary nebulae beyond the limit of the hydrogen series, in the light of the quantum theory and of the Bohr atom.

Early in 1923 Mr. Wright was put in charge of the expedition to observe the eclipse of September 10, 1923, and devoted his time thereafter largely to preparations for the expedition.

The space limits imposed preclude more than a passing reference to studies of the eclipse photographs and spectrograms carried out by Messrs. Moore, Trumpler, and Baker; to computations of orbits of visual and spectroscopic binaries by Messrs. Aitken, Pearce and others; to Mr. Luyten's studies of the relation between mean parallax, proper motion, and apparent magnitude; to the large amount of work done by Mr. Neubauer in computing and applying systematic corrections to certain of the radial velocity measures to reduce all observd velocities to a homogeneous system; and to a number of other details of the year's work. For the same reason it must suffice to say that Mr. Paddock at the Chile Station, working without assistance, secured several hundred spectrograms and measured many of them.

Comparatively few bulletins and other papers were published during the year, but a number of long papers were prepared for the press and will be issued in the coming year. Several volumes of our publications are also being prepared for the press.

LOWELL OBSERVATORY

FLAGSTAFF, ARIZONA

V. M. SLIPHER, concerned chiefly with spectroscopic investigations on planets and nebulae.

C. O. LAMPLAND, concerned chiefly with nebular and radiometric studies.

E. C. SLIPHER, concerned chiefly with visual and photographic observations of the planets.

The work of the Lowell Observatory has continued the program developed under the late Dr. Lowell's leadership, which has as its main problem planetary research, but includes some other studies

chiefly related ot or suggested by the planetary investigations. Consideration is given to the possible development and extension of the work both in the improvement of the equipment and in the adoption of new methods and new lines of attack.

Planetary Observations. Observations with the 24-inch refractor were regularly made of Mars during the 1922 opposition as at previous ones. In connection with the drawings and notes recording the surface features and their changes, micrometric measures of the caps, etc., meridian transits for longitudes of details, numerous large scale photographs in yellow light and series of blue images were secured. Two phenomena—changes in the dark maria and the large tropical white area of July 9 to 12—were of outstanding interest because of the light they throw on Martian changes and his atmosphere.

Jupiter and Saturn were observed visually and their photographic records, begun twenty years ago, were continued, photography of Jupiter being important, for the plate is more able to record faithfully the complex Jovian features than is the observer by drawings and notes. Transits were taken for longitudes of salient markings including the "Red Spot."

Venus and Mercury were observed at opportune times, and visual observations of Uranus included measures of the disk.

Micrometrical measures were made of the position of the fifth satellite of Jupiter, and some visual observations were made of the larger satellites, particularly of III.

Spectrographic Observations. Spectrum observations of the planets during the year have included plates both of rotational displacements and for atmospheric absorption bands. With an improved sensitizing bath the photographic record of the spectrum has been extended still a little farther into the red.

The spectrographic program on nebulae and globular star clusters has been continued as opportunity permitted.

Long exposure spectrograms have been made of a limited region near the north pole, free of lucid stars, for the spectrum of the sky background. Also a plate was secured for the spectrum of the total of sky and star light reflected by a snow-bank. These spectra compared with others of the Milky Way and of star clusters give valuable information as to the quality of the light of the sky background.

Radiometric Investigations. In the summer of 1922 Dr. Coblentz of the Bureau of Standards and Mr. Lampland made radiometric observations chiefly of the planets Mars, Venus, Jupiter and Saturn and of the Sun, employing apparatus by the former attached to the 40-inch Lowell reflector. The results are important for they bring within our reach direct evidence of planetary conditions not obtainable by other means. For example, the measures on Mars indicate an appreciable temperature rise of its surface due to absorbed solar radiation. Further radiometric observations are being made here and it is hoped they

will lead to a more complete interpretation of such data and to a fuller development of this new approach to the study of planetary conditions.

Nebular Observations. Mr. Lampland has continued his systematic observations of nebulae with the Lowell reflector. During the year 408 photographs were made. The work includes objects for which he has reported changes, or which are otherwise of interest, such as the Crab Nebula, Messier 99, his nebulosity about R Aquarii, the strangely located globular cluster N.G.C. 2419 he found in Lynx, and extensive series of the Orion Nebula, Hubble's variable nebula (R Monocerotis), R Coronae Australis, Nova Persei 1901, together with less frequent plates of some well-known spiral nebulae and many novae. A part of his observing time is devoted to photographing objects of the Dreyer catalogues not previously observed with large instruments. Results incidental to this work include many variable stars, some proper motions and his temporary star in spiral nebula N.G.C. 5236.

During the last weeks of the year the energy of the staff was considerably occupied in preparation for observing the solar eclipse of September tenth, but this was largely without avail as our sky at Ensenada was hopelessly cloudy.

Instruments. During the year a powerful conical pendulum driving clock for the 40-inch telescope was completed in the observatory shop and has resulted in a marked gain in the performance and ease of operation of the large reflector. The instrument maker also devoted considerable time to spectrographic equipment and eclipse apparatus. A Fabry-Buisson microphotometer has been added to the equipment.

(To be continued.)

JOHN TYNDALL.

He mapped the rugged shores of thought's frontier;
Where the dull lines of ignorance lay dark
He cruised, till secret places were made clear,
And on dim borders set his finder's mark.

The mysteries of this spinning ball
He solved, and at the door of silence beat.
Nor was alarmed at echoes of his call
That broke afar, his purpose to defeat.

The potent elements of giant force,
The heat and light girt on the earth's great tire
He watched, as fast it flies its channeled course
Along a daily changing track of fire.

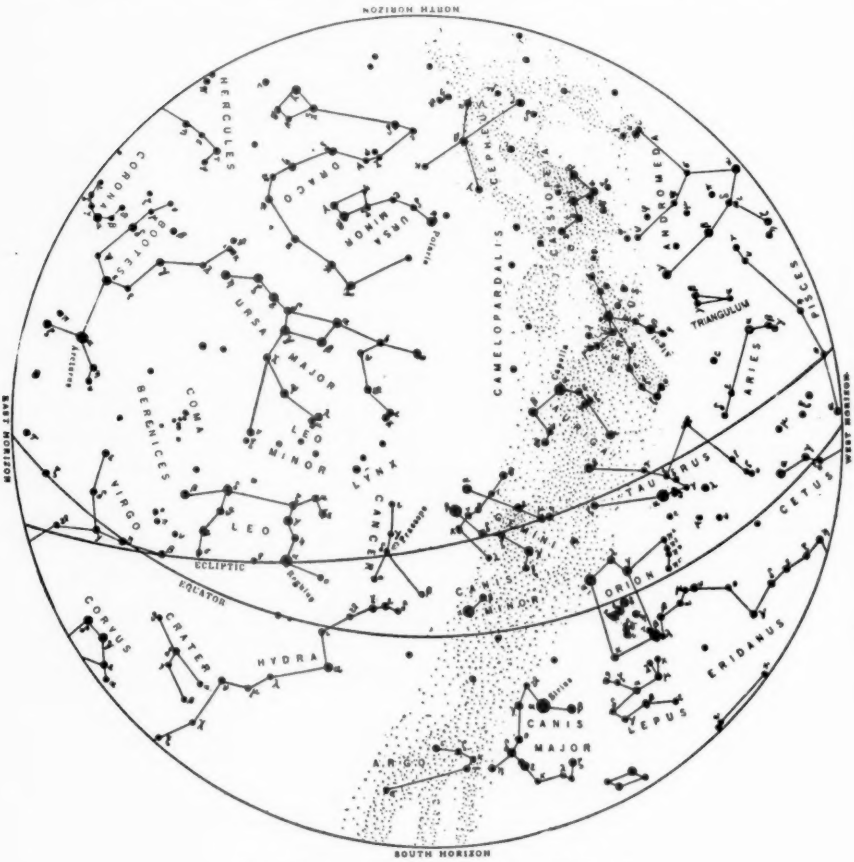
Not as a dreamer who may vigil keep,
Watching the mighty planet spin afar.
But with precision sounding deep on deep,
And linking to his lamp the golden star.

High on the muffled line of ice and snow
He sought where others had not dared to seek;
There knowledge made for him a new dawn glow
To plant his guidon on the farthest peak.

—ANONYMOUS.

PLANET NOTES FOR MARCH.

The *Sun* will pass from the constellation Aquarius into the constellation Pisces during the month. It will cross the equator between three and four o'clock, Central Standard Time, on the afternoon of March 20. The point at which the sun crosses the equator is called the Vernal Equinox and is the start-



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

ing point for measuring distances east and west in the sky, just as Greenwich is the starting point for measuring distances east and west on the earth. The sun usually crosses the Vernal Equinox on March 21, but the date is one day earlier this year, due to the fact that this is a leap year. This is the calendar time for the beginning of spring.

The phases of the *moon* will occur as follows:

New moon	March	5	at 10 A. M.	C.S.T.
First quarter		13	" 11 A. M.	"
Full moon		20	" 10 P. M.	"
Last quarter		27	" 2 P. M.	"

The moon will be farthest from the earth on March 11 and nearest the earth on March 23.

Mercury will be at superior conjunction on March 21. That is, on this date it will pass the sun on the side opposite from the earth. It will pass from the west side of the sun to the east side. Consequently it will be too near the sun to be visible during the month.

Venus will continue to be the brilliant evening star during this month. It will be approaching the earth and will be getting brighter from day to day. At the end of the month its stellar magnitude will be —3.8. This means that it will be more than 80 times as bright as a first magnitude star, such as Aldebaran, and about 200 times as bright as Polaris.

Mars will be visible in the morning sky. At the end of the month it will be a short distance east of the meridian at sunrise. It will be more than twenty-three degrees south of the equator. It will be approaching the earth during the month.

Jupiter will be in quadrature, 90° west of the sun, on March 9. At this time it will be on the meridian at sunrise, and after this date will rise before midnight.

Saturn will rise at the beginning of the month about nine o'clock in the evening, and at the end of the month it will rise soon after sunset. The earth will be sixteen degrees to the north of the plane of the rings, and hence the rings will be easily visible.

Uranus will be in conjunction with the sun on March 7, and consequently will be invisible during the month.

Neptune will be in the opposite part of the sky from the sun, and hence will be visible practically throughout the night this month.

Occultations Visible at Washington.

[*From the American Ephemeris*]

Date 1924		Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle from N	EMERSION. Washington M.T.	EMERSION. Angle from N	Duration
				h m	°	h m	°	h m
Mar. 11	179	B. Tauri	5.9	4 54	97	6 20	232	1 27
11	48	Tauri	6.3	10 23	122	11 12	228	0 49
12	318	B. Tauri	5.7	5 11	84	6 46	254	1 35
14	74	B. Gemin.	6.2	11 8	155	11 47	222	0 39
15		*f* Gemin.	5.3	10 34	95	11 49	291	1 15
21	46	Virginis	6.1	8 49	183	9 11	223	0 22
21	48	Virginis	6.5	10 22	155	11 17	257	0 55
25	90	B. Ophiuchi	6.5	11 44	111	12 44	279	1 1
26	39	g Sagittarii	6.3	17 46	111	19 4	252	1 19
27	171	B. Sagittarii	6.1	13 48	34	14 20	335	0 31
27	190	B. Sagittarii	5.4	16 34	26	17 8	335	0 34

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

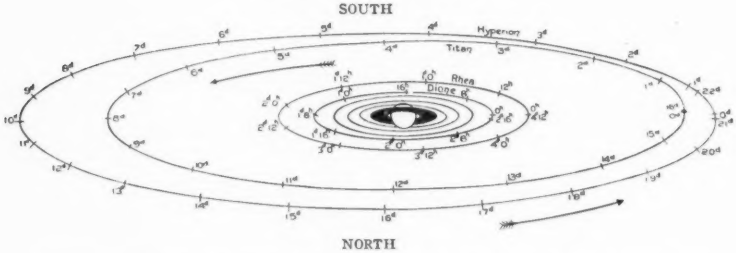
[From the *American Ephemeris.*]

CENTRAL STANDARD TIME, NOON = 0^h

1924		h	m			1924		h	m		
Mar.	1	14	57	I	Oc. R.	Mar.	19	13	48	III	Oc. D.
		15	42	III	Tr. I.			16	5	III	Oc. R.
	2	15	48	II	Sh. I.		20	12	36	II	Sh. E.
	4	14	53	II	Oc. R.			12	46	II	Tr. I.
	7	16	5	I	Sh. I.			15	6	II	Tr. E.
	8	13	24.1	I	Ec. D.		23	14	20	I	Sh. I.
		14	40	III	Sh. I.			15	33	I	Tr. I.
		16	50	III	Sh. E.			16	29	I	Sh. E.
		16	51	I	Oc. R.		24	15	4	I	Oc. R.
	9	13	58	I	Tr. E.		25	12	10	I	Tr. E.
	11	14	55.2	II	Ec. R.		26	12	42.6	III	Ec. D.
		15	5	II	Oc. D.			14	57.2	III	Ec. R.
	15	15	17.4	I	Ec. D.		27	12	50	II	Sh. I.
	16	13	41	I	Tr. I.			15	11	II	Sh. E.
		14	36	I	Sh. E.			15	16	II	Tr. I.
		15	51	I	Tr. E.		29	11	45	II	Oc. R.
	17	13	12	I	Oc. R.		30	16	13	I	Sh. I.
	18	15	7.3	II	Ec. D.		31	13	32.5	I	Ec. D.
		17	29.1	III	Ec. R.						

NOTE:—I. denotes ingress; E, egress; D, disappearance; R, reappearance; Ec, eclipse; Oc, occultation; Tr, Transit of the satellite; Sh, transit of the shadow.

Saturn's Satellites.



Apparent orbits of the seven inner satellites of Saturn at date of opposition, April 18, 1924, as seen in an inverting telescope.

Greatest elongation visible in the United States.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME, NOON = 0^h

I. Mimas. Perod 0^d $22^h.6$.

1924	d	h		d	h		d	h		d	h	
Mar.	1	11.3	W	9	11.6	E	17	11.9	W	25	12.0	E
	2	10.0	W	10	10.3	E	18	10.5	W	26	10.6	E
	3	19.9	E	11	8.9	E	19	9.1	W	27	9.2	E
	4	18.5	E	12	18.8	W	20	19.0	E	28	7.8	E
	5	17.2	E	13	17.4	W	21	17.6	E	28	19.1	W
	6	15.8	E	14	16.1	W	22	16.2	E	29	17.8	W
	7	14.4	E	15	14.7	W	23	14.8	E	30	16.4	W
	8	13.0	E	16	13.3	W	24	13.4	E	31	15.0	W

II. Enceladus. Period $1^d\ 8^h.9$.

1924	d	h		d	h		d	h		d	h	
Mar.	6	19.2	E	Mar. 9	0.4	E	Mar. 17	5.7	E	Mar. 25	11.0	E
	2	4.0	E	10	9.3	E	18	14.6	E	26	19.9	E
	3	12.9	E	11	18.2	E	19	23.5	E	28	4.7	E
	4	21.8	E	13	3.1	E	21	8.4	E	29	13.6	E
	6	6.7	E	14	11.9	E	22	17.2	E	30	22.5	E
	7	15.5	E	15	20.8	E	24	2.1	E			

III. Tethys. Period $1^d\ 21^h.3$.

Mar.	1	21.2	E	Mar. 9	10.3	E	Mar. 16	23.5	E	Mar. 24	12.7	E
	3	18.4	E	11	7.6	E	18	20.8	E	26	10.0	E
	5	15.7	E	13	4.9	E	20	18.1	E	28	7.3	E
	7	13.0	E	15	2.2	E	22	15.4	E	30	4.6	E

IV. Dione. Period $2^d\ 17^h.7$.

Mar.	2	4.2	E	Mar. 10	9.1	E	Mar. 18	14.1	E	Mar. 26	19.1	E
	4	21.8	E	13	2.8	E	21	7.8	E	29	12.8	E
	7	15.5	E	15	20.5	E	24	1.4	E			

V. Rhea. Period $4^d\ 12^h.5$.

Mar.	4	11.6	E	Mar. 13	12.3	E	Mar. 22	13.0	E	Mar. 31	13.6	E
	8	23.9	E	18	0.6	E	27	1.3	E			

VI. Titan. Period $15^d\ 23^h.3$.

Mar.	1	20.2	W	Mar. 9	18.6	E	Mar. 17	18.1	W	Mar. 25	16.4	E

VII. Hyperion. Period $21^d\ 7^h.6$

Mar.	12	0.8	E	Mar. 21	19.0	W						

NOTE—E, Eastern Elongation; W, Western Elongation.

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1924 March					
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7					27	21
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7	2 3	10 6	18 9		26	13
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 1	11 19	19 13		27	6
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	10 17		25 12			
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	1 20	9 19	17 17		25	16
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	4 3	11 22	19 17		27	12
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		15 13			31	22
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 14	15 4	23 18			
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	6 8	17 11	28 15			
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	4 16	16 7	27 22			
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	5 15	13 7	20 23		28	15
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	9 21	20 1	30 4			
Y Aurigæ	21.5	+42 21	8.6— 9.6	3 20.6	4 14	12 7	20 0		27	18
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3 7	14 8	19 21		30	22
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 4	13 17	21 7		28	21
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3			23 11			
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	1 16	9 3	24 1		31	12
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	5 1	13 0	20 21		28	19
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 11	13 14	23 18			

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1924 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
RU Camelop	7	10.9	+69	51	8.5— 9.8	22	06.5			10	14				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	2	8	10	7	18	6	26	4
V Carinae	8	26.7	—59	47	7.4— 8.1	6	16.7	5	22	11	15	19	10	26	0
T Velorum	8	34.4	—47	01	7.6— 8.5	4	15.3	1	13	10	19	20	2	29	9
V Velorum	9	19.2	—55	32	7.5— 8.2	4	08.9	5	20	14	15	23	8		
Z Leonis	9	46.4	+27	22	7.9— 9.6	56	08.7					20	02		
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	4	14	11	9	24	23	31	18
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	4	1	10	16	23	21	30	12
S Muscae	12	07.4	—69	36	6.4— 7.3	9	15.8	1	0	10	16	20	8	30	0
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	7	16	15	16	23	15	31	15
T Crucis		15.9	—61	44	6.8— 7.6	6	17.6	2	12	9	6	22	17	29	11
R Crucis		18.1	—61	04	6.8— 7.9	5	19.8	1	5	12	21	18	16	30	8
S Crucis	12	48.4	—57	53	6.5— 7.6	4	16.6	3	15	13	0	22	9	31	18
W Virginis	13	20.9	—	2 52	8.7—10.4	17	06.5	3	2			20	9		
SS Hydræ		25.0	—23	08	7.4— 8.1	8	04.8	3	14	11	19	20	0	28	5
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	5	6	12	6	19	7	26	7
ST Virginis	14	22.5	—	0 27	10.3—11.4	0	09.9	2	23	11	5	19	10	27	16
V Centauri		25.4	—56	27	6.4— 7.8	5	11.9	3	19	14	19	20	6	31	6
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	6	2	13	15	21	4	28	17
R Triang.Austr.	15	10.8	—66	08	6.7— 7.4	3	09.3	2	9	9	3	22	17	29	11
S Triang.Austr.	15	52.2	—63	29	6.4— 7.4	6	07.8	5	11	11	19	24	10	30	18
S Normæ	16	10.6	—57	39	6.6— 7.6	9	18.1	10	11	20	5	29	23		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	2	14	11	11	20	8	29	4
RV Scorpii	16	51.8	—33	27	6.7— 7.4	6	01.5	7	15	13	16	25	19	31	20
X Sagittarii	17	41.3	—27	48	4.4— 5.0	7	00.3	2	20	9	20	23	21	30	21
Y Ophiuchi		47.3	—	6 07	6.1— 6.5	17	02.9	1	2					28	5
W Sagittarii	17	58.6	—29	35	4.3— 5.1	7	14.3	3	12	11	3	18	17	26	7
Y Sagittarii	18	15.5	—18	54	5.4— 6.2	5	18.6	7	7	13	1	24	15	31	9
U Sagittarii		26.0	—19	12	6.5— 7.3	6	17.9	6	18	13	12	20	6	27	0
Y Scuti		32.6	—	8 27	8.7— 9.2	10	08.3	3	21	15	6	25	14		
RZ Lyræ		39.9	+32	42	9.9—11.2	0	12.3	4	7	10	11	22	17	28	20
RT Scuti	18	44.1	—10	30	9.1— 9.7	0	11.9	4	6	10	5	22	2	28	1
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	3	8	12	10	21	13	30	15
U Aquilæ	19	24.0	—	7 15	6.2— 6.9	7	00.6	7	20	14	20	21	21	28	21
XZ Cygni	19	30.4	+56	10	8.6— 9.3	0	11.2	2	20	9	20	23	20	30	20
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	3	2	11	2	19	1	27	1
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	2	14	10	7	17	23	25	16
η Aquilæ		47.4	+	0 45	3.7— 4.5	7	04.2	3	0	10	4	24	12	31	17
S Sagittæ		51.5	+16	22	5.6— 6.4	8	09.2	7	5	15	14	23	23		
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	1	6	7	14	20	5	26	13
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3			11	3			27	13
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	2	14	11	11	20	8	29	5
UY Cygni		52.3	+30	03	9.6—10.4	0	13.5	1	18	8	12	21	23	28	16
RV Capric.		55.9	—15	37	9.2—10.1	0	10.7	1	12	8	5	21	15	28	9
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	5	16			20	9		
VY Cygni	21	00.4	+39	34	8.8— 9.5	7	20.6	7	23	15	20	23	17	31	13
SW Aquarii		10.2	—	0 20	9.9—10.8	0	11.0	4	21	11	18	18	16	25	13
VZ Cygni	21	47.7	+42	40	8.2— 9.2	4	20.7	2	1	11	18	21	12	31	5
Y Lacertæ	22	05.2	+50	33	9.1— 9.6	4	07.8	8	0	16	15	25	7		
δ Cephei		25.5	+57	54	3.7— 4.6	5	08.8	6	3	11	12	22	6	27	15
Z Lacertæ		36.9	+56	18	8.2— 9.0	10	21.1			10	16	21	14		
RR Lacertæ		37.5	+55	55	8.5— 9.2	6	10.1	7	4	13	14	20	0	26	10
V Lacertæ		44.5	+55	48	8.5— 9.5	4	23.6	2	18	12	18	17	17	27	17
X Lacertæ	22	45.0	+55	54	8.2— 8.6	5	10.7	5	5	10	16	21	13	27	0
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	2	14	13	12	18	22	29	19
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	4	21	11	4	23	18	30	1
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	2	3	14	6	26	9		
V Cephei	23	51.7	+82	38	6.0— 7.0	0	23.9	4	8	11	7	18	7	25	6

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1924 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8							25	13
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	5 4	12	21	20	13	28	5	
U Cephei	0 53.4	+81 20	7.0— 9.0	1 11.8	2 7	9	18	17	6	24	18	
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	1 9	7	12	19	17	25	20	
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 6	10	20	19	9	27	23	
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 15	11	11	18	8	25	5	
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3 1	10	5	17	9	24	13	
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	4 23	13	18	22	12	31	7	
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 13	13	12	21	11	29	10	
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6								
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2 0	10	14	19	5	27	19	
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3 8	10	3	23	18	30	13	
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	2 0	9	22	17	19	25	17	
RW Tauri	3 57.8	+27 51	7.1— [11	2 18.5	1 13	9	21	18	4	26	11	
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	2 11	10	8	18	6	26	3	
RW Persei	13.3	+42 04	8.8—11.0	13 04.8		13	0			27	4	
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	1 14	7	21	20	11	26	18	
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	2 12	14	22	27	8			
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	1 9	8	0	21	8	28	0	
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2 18	10	22	19	2	27	7	
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	2 20	8	20	20	21	26	22	
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	4 5	12	21	21	13	30	5	
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	3 3	13	13	23	22			
SV Gemin.	54.6	+24 28	9.8— [11	4 00.2	1 7	9	7	17	7	25	7	
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 7	11	0	22	11	28	5	
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	3 10	10	0	21	5	26	19	
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	6 1	14	6	22	10	30	15	
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	3 19	11	10	19	1	26	16	
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		9	14	21	19			
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	7 16	14	20	22	0	29	4	
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	3 4	9	23	23	15	30	10	
RY Gemin.	21.7	+15 52	8.9— [10	9 07.2	1 18	11	1	20	8	29	15	
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	4 18	11	9	24	14	31	5	
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	1 22	10	8	18	17	27	3	
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	5 1	11	11	24	8	30	18	
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	4 21	12	4	19	10	26	17	
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	2 7	10	10	18	13	26	16	
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	4 0	13	11	22	23			
RX Hydrae	9 00.8	— 7 52	9.1—10.5	2 06 8	6 6	13	2	19	23	26	19	
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	5 8	11	6	23	3	29	1	
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2 20	9	14	23	2	29	20	
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	6 3	13	13	20	23	28	9	
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	6 13	13	4	19	18	26	9	
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	7 5	16	0	24	19			
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1 3	8	11	23	3	30	11	
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7 6	14	1	20	20	27	14	
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	3 5	10	17	18	5	25	17	
RS Can. Ven	13 06.3	+36 28	7.5—12.5	4 19.1	3 1	12	16	22	6	31	20	
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	6 9	13	20	21	6	28	17	
SX Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	3 11	9	6	20	20	26	15	

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1924 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	5 18	12 18	19 17	26 17				
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	7 16	14 13	21 11	28 9				
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.4	6 13	14 23	23 9	31 19				
SS Libræ	15 43.4	—15 14	9.3—11.5	0 18.4	1 7	8 11	22 20	30 1				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	5 8	12 16	20 0	27 8				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	5 14	13 20	22 2	30 8				
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	3 23	12 19	21 16	30 12				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1		15 18						
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	3 14	10 9	24 0	30 19				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	3 19	12 4	20 13	28 22				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	7 9	13 13	19 16	25 20				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 1	8 5	20 14	26 18				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	4 22	12 7	19 16	27 1				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 14	9 18	17 23	25 3				
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	2 11	10 0	17 12	25 1				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	2 17	10 11	18 5	25 23				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	1 23	9 22	17 21	25 21				
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	2 23	11 12	20 0	28 12				
WY Sagittarii	17 54.9	—23 01	9.5—10.6	4 16.0	3 15	12 23	22 7	31 16				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	2 13	12 21	18 1	28 9				
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	2 16	9 22	24 9	31 15				
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	6 3	13 1	19 23	26 20				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	1 2	16 5	31 9					
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4 17	11 21	19 1	26 5				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	3 22	11 0	18 3	25 6				
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	1 21	10 4	18 11	26 19				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	1 19	10 7	18 19	27 7				
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	3 10	10 2	23 8	30 0				
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	6 14		19 12					
U.Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	6 1	13 17	21 8	28 23				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	7 3	14 17	22 6	29 20				
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	4 15	11 20	19 1	26 5				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	8 1	17 0	25 23					
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	2 16	9 10	22 23	29 17				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	5 14	12 23	20 8	27 16				
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	4 9	14 21	20 3	30 15				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	1 14	8 2	21 3	27 16				
SY Cygni	19 42.7	+32 28	10. —12	6 00.2	6 4	12 4	24 4	30 5				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	7 7	13 22	20 13	27 5				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	5 10	9 23	19 3	23 17				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 15	15 1	23 11	31 22				
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	4 19	11 13	25 3	31 22				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	6 16	13 14	20 12	27 9				
V Vulpec	32.3	+26 15	8.2— 9.8	37 19.0		11 1						
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	9 9	19 0	28 14					
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	9 15	18 20	28 1					
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8 17	17 17	26 17					
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	7 13	15 3	22 18	30 8				
RR Vulpec	20 50.5	+27 32	9.6—11.0	5 01.2	3 21	13 23	24 2					
RY Aquarii	21 14.8	—11 14	8.8—10.4	1 23.2	2 17	10 14	18 11	26 8				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	6 18							
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	2 19	12 22	23 2					
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	2 11	7 15	18 0	28 9				
VW Pegasi	51.7	+32 42	10.0—10.6	5 06.4	2 8	12 21	18 3	28 16				
Y Piscium	23 29.3	+ 7 22	9.0—12.0	3 18.4	4 18	12 7	19 20	27 9				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	7 19	16 1	24 7					

Monthly Report of the American Association of Variable Star Observers, November 20 to December 20, 1923.

In spite of reported inclement and cloudy weather from many sections, the amount of observational material received has been fully up to expectations, Messrs. Peltier, Chandra, Bouton and Baldwin contributing exceptionally valuable and lengthy reports.

Mira, o Ceti, is rising to maximum rapidly and is now visible to the unaided eye. This should give our observers without telescopes a chance to try their skill at observng this interesting and time honored variable. χ Cygni has been well observed during its recent maximum and is now slowly declining in light. SS Cygni underwent two peculiar increases in light during December, both slowly-rising types. This star has passed through 200 maxima since its discovery in 1896. (See P. A. Vol. XXXI, 313, 1923 for light curve.)

The Secretary, Mr. W. T. Olcott, has gone to Useppa Isle for the balance of the winter season. Dr. Shapley has kindly offered his services as lecturer in the interests of the AAVSO Pickering Memorial Fund, and gives his first lecture before the Rotary Club in New York City on February 5, immediately followed by others in Miami and St. Petersburg, Florida.

At Miami, Fla., Mr. S. Lynn Rhorer will re-establish his astronomical observing center, as he did last winter, and attempt, with an additional 5-inch telescope, to interest the public there in astronomical matters. Last season he had several thousand visitors within a few weeks. It is of interest to report that the 10-inch refractor recently erected at Mt. Kisco, N. Y., by Mr. Arthur W. Butler is a working success. We hope soon to have some good reports from Mr. Butler. This refractor is the largest instrument so far erected by an amateur in our Association for the observation of variable stars.

Mr. W. A. Mason, formerly of Germantown, Pa., one of our late members, passed away on December 23. He was particularly interested in the problem of Algol, having computed ephemerides for many years, by a short method of his own device. He had been in charge of drawing in the Philadelphia schools for forty years and had contributed numerous articles on astronomy to the popular magazines, besides publishing several valuable books on art. To the few of us who knew him intimately, his loss will be keenly felt.

Again we are indebted to Mr. J. H. Skaggs of Oakland, Cal., for presenting to the members of the Association copies of the Julian Day Calendar for 1924. A few extra copies are also available for distribution to astronomers and observatories not directly connected with the Association. Mr. D. F. Brocchi, of Seattle, Wash., has also kindly furnished our active members with blue-print copies of his very attractive and useful Julian Day Calendar for the same year. Both calendars will prove most helpful to our members.

The following persons have been recently elected to membership in the Association:

Mr. F. C. Deering, Saco, Maine	Life
Mr. Stephen Cummings, Norway, Maine	Life
Mr. Hans Gaebler, Watertown, Wis.	Life
Miss Helen Howarth, Northampton, Mass.	Annual
Mr. J. A. Biernel, Pittsburgh, Pa.	Annual
Mr. R. I. Wolff, New York, N. Y.	Annual
Mr. Samuel L. Thorndike, Boston, Mass.	Annual

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
000339 V SCULPTORIS—						
	3701.0	13.0	Bl,	3718.0	12.2	Bl.
	3708.0	12.1	Bl,			
001032 S SCULPTORIS—						
	3701.0	8.7	Bl,	3729.0	7.5	Kd,
	3708.0	8.3	Bl,	3732.9	7.5	Kd,
	3718.0	7.8	Bl,	3736.9	7.5	Kd,
	3722.0	8.1	Kd,	3749.9	7.0	Kd,
	3727.0	7.8	Kd,	3765.5	6.9	Pt.
001046 X ANDROMEDAE—						
	3745.6	10.1	B,	3759.6	10.4	B.
001620 T CETI—						
	3703.4	5.4	An,	3734.9	6.0	Kd,
	3722.0	6.0	Kd,	3739.0	5.9	Kd,
	3726.9	6.0	Kd,	3746.9	5.8	Kd,
	3730.4	5.4	An,	3753.4	5.4	An,
	3730.9	5.9	Kd,			
001726 T ANDROMEDAE—						
	3756.7	13.4	B,	3764.7	13.0	Pt.
001755 T CASSIOPEIAE—						
	3729.7	8.2	L,	3763.6	8.8	Sg,
	3745.6	8.3	B,	3764.7	8.2	Pt,
	3752.6	9.1	Sg,	3765.6	9.4	Ya,
	3759.6	8.7	B,	3767.6	8.9	B,
	3763.4	8.9	Ca,	3771.8	9.1	Ca.
001838 R ANDROMEDAE—						
	3764.7	14.3	Pt,	3767.8	14.1	Pa.
001868 S TUCANAE—						
	3701.1	12.7	Bl,	3724.0	13.8	Bl.
001909 S CETI—						
	3725.1	8.9	Ch,	3749.7	9.5	Sg.
	3727.0	9.5	Kd,	3752.5	9.6	Ya,
	3731.1	8.8	Ch,	3761.5	10.1	Ca,
	3736.5	8.8	Ya,	3762.6	10.1	Sg,
	3737.1	9.0	Kd,	3765.5	10.0	Pt.
	3746.2	9.2	Ch,			
002546 T PHOENICIS—						
	3701.1	13.6	Bl.			
002833 W SCULPTORIS—						
	3701.1	12.9	Bl.			
003179 Y CEPHEI—						
	3760.8	14.9.	Pa.			
004047 U CASSIOPEIAE—						
	3760 8	14.4	Pa.			
004132a RW ANDROMEDAE—						
	3732.1	8.8	Ch,	3764.7	10.1	Pt.
	3759.7	9.8	B,			
004435 V ANDROMEDAE—						
	3762.6	12.3	B.			
004435 X SCULPTORIS—						
	3701.1	13.1	Bl.			
004533 RR ANDROMEDAE—						
	3759.7	9.8	B,	3768.6	9.6	Hu.
004746a RV CASSIOPEIAE—						
	3729.7	9.5	L,	3760.6	9.9	B,
	3745.6	9.7	B,	3765.5	9.9	Pt.
004958 W CASSIOPEIAE—						
	3748.7	11.8	B,	3764.7	12.0	Pt.
	3762.6	11.2	B,			
005475 U TUCANAE—						
	3701.1	14.0	Bl,	3724.0	13.3	Bl.
010102 Z CETI—						
	3759.6	11.3	B,	3764.7	11.5	Pt.
010630 U SCULPTORIS—						
	3701.1	11.3	Bl,	3718.0	10.0	Bl.
	3708.0	10.7	Bl,			
010940 U ANDROMEDAE—						
	3767.8	14.1	Pa.			
011208 S PISCIUM—						
	3735.7	10.0	Pa,	3762.7	10.9	B,
	3756.5	10.6	Pa,	3764.5	10.7	Pa.
011272 S CASSIOPEIAE—						
	3743.6	10.6	Pi.	3764.7	10.3	Pt,
	3757.6	10.5	Sg,	3765.6	10.6	Ya,
	3759.6	10.0	B,	3767.6	10.0	B.
011712 U PISCIUM—						
	3764.7	13.6	Pt.			
012233a R SCULPTORIS—						
	3727.0	7.9	Kd,	3749.9	7.6	Kd.
012350 RZ PERSEI—						
	3765.7	10.9	B.			
012502 R PISCIUM—						
	3767.8	14.2	Pa.			
013238 RU ANDROMEDAE—						
	3764.7	11.6	Pt,	3765.7	12.2	B.
013338 Y ANDROMEDAE—						
	3732.1	12.5	Ch,	3764.7	14.2	Pt.
014958 X CASSIOPEIAE—						
	3748.7	10.7	B,	3762.6	10.8	B.
	3756.5	12.2	Pt,			
015354 U PERSEI—						
	3750.6	8.8	Sg,	3756.5	8.4	Pt,
	3753.6	8.8	B,	3764.6	8.4	B.
015912 S ARIETIS—						
	3765.5	14.4	Pt.			
021024 R ARIETIS—						
	3729.7	7.8	L,	3765.5	7.9	Ly,
	3741.6	7.8	B,	3765.5	8.0	Pt,
	3751.7	8.3	Kl,	3765.7	9.0	Cy,
	3756.6	8.4	Kl,	3767.7	8.5	Kl,
	3758.5	8.0	Ca,	3768.7	8.3	Ca.
	3762.7	9.0	Br,	3769.6	8.6	Kl.
	3763.5	7.8	Ly,	3772.6	8.6	Kl.
	3764.7	8.6	Kl,			
021143a W ANDROMEDAE—						
	3762.7	8.0	Br,	3764.7	7.0	Pt.
021258 T PERSEI						
	3764.7	8.5	Pt.			
021281 Z CEPHEI—						
	3743.6	11.6	Pi	3760.6	11.8	B.
	3760.5	12.0	Pt,			
021403 o CETI—						
	3725.1	9.1	Ch,	3762.6	8.8	Ms,
	3703.4	9.1	An,	3762.6	8.5	Sg,
	3730.4	9.1	An,	3764.6	8.6	Kl,
	3750.0	9.0	Ch,	3764.7	8.4	Pt.
	3751.7	9.0	Kl,	3765.5	8.6	Ms,
	3753.4	9.2	An,	3765.5	8.6	Ly,
	3755.6	8.9	Hr,	3765.6	8.5	Cy,
	3755.6	9.0	Cy,	3765.6	8.7	Hr,
	3755.8	8.8	O,	3767.6	8.5	Kl,
	3756.6	9.0	Gb,	3768.6	8.2	Ca,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
021403 o CETI—Continued.						
	3756.6	8.8	Kl.	3769.5	8.4	Ms.
	3759.6	8.9	Kl.	3772.6	7.8	Kl.
	3761.5	8.7	Ca.	3773.5	7.7	Ca.
	3761.5	8.8	Ms.			
021558 S PERSEI—						
	3731.1	9.0	Ch.	3764.6	8.5	B.
	3749.6	8.7	Ym.	3764.7	8.5	Pt.
	3753.6	8.6	B.			
022000 R CETI—						
	3725.2	9.2	Ch.	3761.5	11.8	Ca.
	3751.6	10.7	Ca.			
022150 RR PERSEI—						
	3765.5	13.0	Pt.			
022426 R FORNACIS—						
	3701.1	8.5	Bl.	3718.0	8.0	Bl.
	3708.0	8.5	Bl.			
022813 U CETI—						
	3756.6	12.3	B.	3765.5	12.6	Pt.
022980 RR CEPHEI—						
	3728.7	12.9	L.	3765.5	13.0	Pt.
023133 R TRIANGULI—						
	3765.5	11.0	Pt.	3765.7	11.7	Cy.
	3765.6	11.5	Ya.			
024356 W PERSEI—						
	3692.6	9.8	Cm.	3763.4	9.1	Ca.
	3720.6	9.4	Cm.	3765.5	93	Pt.
	3726.6	9.9	Cm.	3765.7	9.6	Cy.
	3727.6	9.9	Cm.	3765.7	9.5	Hr.
	3753.6	9.6	B.	3770.6	9.6	M.
	3761.6	9.7	Cm.	3771.8	9.3	Ca.
025050 R HOROLOGII—						
	3701.1	6.8	Bl.	3718.0	7.3	Bl.
	3708.0	6.8	Bl.			
025751. T HOROLOGII—						
	3701.1	8.0	Bl.	3718.0	8.4	Bl.
	3708.0	8.6	Bl.			
030514 U ARIETIS—						
	3760.6	14.5	B.	3760.8	14.9	Pa.
031401 X CETI—						
	3729.6	12.6	L.	3756.6	10.0	B.
	3754.7	10.0	Br.	3765.5	9.5	Pt.
032043 Y PERSEI—						
	3742.6	8.4	Ym.	3755.6	8.5	B.
	3752.6	8.0	Gd.	3765.5	8.4	Pt.
032335 R PERSEI—						
	3744.6	8.4	Ym.	3763.5	9.8	Ca.
	3752.6	8.9	Hu.	3765.5	10.2	Pa.
	3754.7	9.3	Br.	3765.5	9.9	Pt.
032443 NOVA *PERSEI* #2—						
	3749.6	12.8	Ym.			
042209 R TAURI—						
	3760.8	14.4	Pa.	3765.5	13.8	Pt.
042215 W TAURI—						
	3724.7	10.8	Sg.	3761.5	11.0	Gd.
	3736.8	10.9	Sg.	3762.6	11.0	Sg.
	3738.8	10.6	Sg.	3764.6	10.8	Kl.
	3751.7	10.8	Kl.	3764.7	10.5	Pt.
	3752.6	10.6	Hu.	3765.6	11.1	Fi.
	3755.7	10.4	Hr.	3765.7	10.5	Cy.
042215 W TAURI—Continued.						
	3755.7	10.9	Cy.	3767.6	10.7	Kl.
	3756.6	10.7	Kl.	3769.6	10.9	Kl.
	3759.6	10.8	Kl.	3772.6	10.9	Kl.
043055 T CAMELOPARDALIS—						
	3728.7	12.1	L.	3764.7	13.6	Pt.
	3761.6	13.5	Br.			
043208 RX TAURI—						
	3766.6	13.2	B.			
043262 R RETICULAE—						
	3701.1	12.2	Bl.			
043274 X CAMELOPARDALIS—						
	3755.6	11.3	B.	3766.6	10.7	B.
	3764.7	10.7	Pt.			
043562 R DORADUS—						
	3701.1	5.8	Bl.			
044349 R PICTORIS—						
	3701.1	7.1	Bl.	3718.0	7.0	Bl.
	3708.0	7.2	Bl.			
044617 V TAURI—						
	3751.6	9.1	B.	3763.6	9.7	B.
	3755.5	9.7	O.	3764.7	9.8	Pt.
	3761.5	10.2	Gd.			
045307 R ORIONIS—						
	3745.7	10.1	B.	3760.0	10.9	B.
045514 R LEPORIS—						
	3727.2	7.5	Ch.	3762.6	7.2	Ms.
	3738.2	7.0	Ch.	3764.7	6.7	Pt.
	3755.6	6.9	B.	3768.7	7.5	Ca.
	3761.6	6.9	Ms.			
050003 V ORIONIS—						
	3764.7	14.5	Pt.			
050022 T LEPORIS—						
	3701.1	10.8	Bl.	3755.7	9.0	B.
	3708.0	10.7	Bl.	3764.7	8.8	Pt.
	3718.0	9.8	Bl.			
050848 S PICTORIS—						
	3701.1	12.5	Bl.	3718.0	11.8	Bl.
	3708.0	12.5	Bl.			
050953 R AURIGAE—						
	3755.6	10.4	B.	3764.7	9.4	Pt.
	3763.5	9.9	Ca.	3766.6	9.8	B.
051247 T PICTORIS—						
	3701.1	11.6	Bl.			
051533 T COLUMBAE—						
	3701.1	8.3	Bl.	3718.0	8.8	Bl.
	3708.0	8.5	Bl.			
052034 S AURIGAE—						
	3728.2	10.5	Ch.	3763.6	9.5	B.
	3729.7	10.6	L.	3763.7	9.5	Sø.
	3751.7	9.4	B.	3764.7	9.2	Pt.
052036 W AURIGAE—						
	3728.2	9.2	Ch.	3764.7	11.0	Pt.
	3755.5	10.8	O.	3766.6	11.0	B.
	3755.6	10.5	B.			
052401 S ORIONIS—						
	3745.7	8.1	B.	3768.6	8.5	Ca.
	3759.7	8.6	B.	3769.8	9.5	M.
	3761.6	8.3	Ca.	3773.7	8.9	Ca.
	3764.7	8.4	Pt.			

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
053005a T ORIONIS—						
	3729.7	10.1	L,	3764.7	10.7	Pt,
	3742.8	10.0	Pt,	3764.8	10.5	Sg,
	3745.7	10.4	B,	3765.5	10.3	Pt,
	3750.8	10.0	Sg,	3768.6	11.0	Hu,
	3755.7	11.0	Pt,	3768.9	10.4	Pt,
	3759.7	11.3	B,	3769.8	10.5	M.
053068 S CAMELOPARDALIS—						
	3764.7	8.3	Pt.			
053326 RR TAURI—						
	3756.6	12.0	B.			
053531 U AURIGAE—						
	3754.6	12.7	B,	3766.7	12.9	B.
	3764.7	12.5	Pt.			
054319 SU TAURI—						
	3726.2	9.7	Ch,	3760.7	9.7	B,
	3729.7	9.4	L,	3764.7	9.5	B,
	3741.6	9.5	B,	3764.7	9.5	Pt,
	3742.8	9.5	Pt,	3765.5	9.5	Pt,
	3744.7	9.6	Ym,	3767.5	9.5	Pt,
	3745.6	9.5	B,	3768.5	9.5	Pt,
	3755.6	9.5	B,	3769.8	9.6	M,
	3755.7	9.6	Pt,	3769.9	9.6	Pt,
	3758.5	9.4	Cd,	3771.5	9.6	Pt,
	3760.5	9.6	Pt,	3772.5	9.5	Pt.
054331 S COLUMBAE—						
	3701.1	12.7	Bl.			
054629 R COLUMBAE—						
	3701.1	11.4	Bl,	3708.0	11.8	Bl.
054920a U ORIONIS—						
	3745.7	8.9	B,	3764.6	9.0	Kl,
	3751.7	8.4	Kl,	3764.7	8.8	Pt,
	3752.6	8.9	Hu,	3763.7	9.2	Sg,
	3755.7	9.5	Hr,	3765.8	9.6	Cy,
	3755.7	9.8	Cy,	3767.6	8.9	Kl,
	3756.6	8.9	Gb,	3769.6	9.0	Kl,
	3756.6	8.7	Kl,	3769.8	9.2	M,
	3759.7	9.0	Kl,	3771.8	9.1	Ca,
	3960.6	8.8	B,	3772.6	9.3	Kl.
	3761.6	9.0	Ca,			
054920b UW ORIONIS—						
	3755.7	10.6	Hr,	3765.8	10.5	Cy.
	3755.7	10.5	Cy,			
054974 V CAMELOPARDALIS—						
	3760.8	[16.0	Pa.			
055353 Z AURIGAE—						
	3729.2	10.5	Ch,	3762.7	10.7	B,
	3755.6	10.7	B,	3764.7	10.7	Pt.
	3760.6	10.5	B,	3769.8	10.7	M.
055686 R OCTANTIS—						
	3701.1	9.8	Bl,	3718.0	8.4	Bl.
	3708.0	9.0	Bl,			
060450 X AURIGAE—						
	3744.7	10.0	Ym,	3763.6	9.2	B,
	3751.7	9.3	B,	3764.7	9.1	Pt.
	3757.5	9.7	O,			
060547 SS AURIGAE—						
	3725.2	[11.4	Ch,	3754.7	[13.3	Br,
	3727.2	[11.4	Ch,	3755.5	[12.4	O,
	3728.2	[11.4	Ch,	3755.6	[13.4	B,
	3728.6	[13.3	L,	3755.7	[14.9	Sg,
060547 SS AURIGAE—Continued.						
	3729.2	[11.0	Ch,	3755.7	[12.6	Pt,
	3729.7	[14.0	L,	3755.6	[13.3	Kl,
	3731.2	[11.0	Ch,	3759.6	[12.6	Kl,
	3732.2	[11.0	Ch,	3760.5	[12.6	Pt,
	3733.2	[11.4	Ch,	3760.8	15.6	Pa,
	3735.2	[11.4	Ch,	3762.6	[11.8	Sg,
	3736.2	[11.4	Ch,	3762.7	[13.3	B,
	3738.2	10.9	Ch,	3762.7	[13.3	Br.
	3738.8	11.1	Sg,	3762.7	[13.5	Ym,
	3741.6	12.2	B,	3764.6	[13.0	Kl,
	3741.7	[11.8	Sr,	3764.7	[13.8	B,
	3742.8	13.0	Pt,	3764.7	[13.3	Sg,
	3743.5	[12.4	Cd,	3764.7	[12.6	Pt,
	3743.6	12.0	Pi,	3765.5	[12.6	Pt.
	3744.2	[11.0	Ch,	3765.5	[11.8	Kl,
	3744.7	[12.6	Ym,	3765.6	[12.5	Ym,
	3745.7	[12.5	B,	3766.6	[12.5	Ym,
	3746.7	[11.0	Ym,	3767.5	[12.6	Pt,
	3749.6	[12.4	Ym,	3767.6	[12.6	Kl,
	3750.7	[12.4	Sg,	3768.5	[12.4	Pt,
	3751.1	[11.4	Ch,	3769.5	[12.6	Kl,
	3751.6	[12.5	Ym,	3769.9	[12.6	Pt.
	3751.7	[12.6	Kl,	3770.6	[12.4	M.
	3752.4	[13.5	Cd,	3771.5	[11.0	Pt,
	3752.6	[12.6	Ym	3772.5	[11.0	Pt,
	3754.7	[13.5	B,	3772.6	[11.8	Kl.
061647 V AURIGAE—						
	3745.7	9.8	B,	3760.6	10.6	B.
	3757.5	11.0	O,			
061702 V MONOCEROTIS—						
	3764.7	12.3	Pt.			
063159 U LYNCIS—						
	3755.5	9.3	O.			
063308 R MONOCEROTIS—						
	3762.7	11.8	B,	3764.7	11.5	Pt.
063558 S LYNCIS—						
	3764.7	14.0	Pt.			
064030 X GEMINORUM—						
	3755.7	9.2	B,	3770.6	10.4	M.
064707 W MONOCEROTIS—						
	3764.7	10.4	Pt.			
065111 Y MONOCEROTIS—						
	3764.7	11.2	Pt.			
065355 R LYNCIS—						
	3755.7	12.1	B.			
070122a R GEMINORUM—						
	3755.7	7.0	Pt,	3768.6	7.5	Hu,
	3761.6	7.0	Ca,	3769.7	7.6	Pa,
	3766.4	7.6	Al,	3771.7	7.8	Pa.
	3768.6	7.2	Ca,			
070122b Z GEMINORUM—						
	3755.7	12.6	Pt.			
070122c TW GEMINORUM—						
	3755.7	7.7	Pt,	3768.6	8.0	Ca.
	3761.6	8.1	Ca,			
071713 V GEMINORUM—						
	3755.7	8.4	Pt.			
072708 S CANIS MINORIS—						
	3755.7	12.0	Pt,	3765.7	12.2	Cy.

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
072811 T CANIS MINORIS—						
	3755.7	10.0	Pt.			
073173 S VOLANTIS—						
	3701.1	10.8	Bl,	3718.0	10.5	Bl.
	3708.0	10.8	Bl,			
073508 U CANIS MINORIS—						
	3755.7	9.6	Pt.			
073723 S GEMINORUM—						
	3764.7	13.8	Pt.			
074241 W PUPPIS—						
	3701.1	13.1	Bl,	3707.3	13.6	Bl.
074323 T GEMINORUM						
	3764.7	12.9	Pt,	3765.7	12.8	B.
074922 U GEMINORUM—						
	3728.2	[11.4	Ch,	3762.7	[13.7	B,
	3728.7	[13.0	L,	3764.7	[13.7	B,
	3729.2	[11.4	Ch,	3764.7	[13.3	Pt,
	3729.7	14.1	L,	3764.7	[12.6	Kl,
	3733.2	[11.4	Ch,	3765.7	[13.8	B,
	3735.3	[11.4	Ch,	3765.9	[13.3	Pt,
	3736.2	[11.4	Ch,	3767.7	[12.6	Kl
	3738.2	[12.4	Ch,	3768.9	[12.4	Pt,
	3742.8	[12.4	Pt,	3769.9	[13.3	Pt,
	3744.7	[12.4	Ym,	3770.6	[12.4	M,
	3755.7	[13.3	Pt,	3772.6	[12.3	Kl,
	3756.6	[12.6	Kl,	3772.9	[13.3	Pt.
081112 R CANCRI—						
	3764.7	9.4	Pt.			
081617 V CANCRI—						
	3764.7	12.5	Pt.			
082405 RT HYDRAE—						
	3764.7	7.8	Pt.			
082476 R CHAMAELEONTIS—						
	3701.1	10.8	Bl,	3718.0	11.5	Bl.
	3708.0	10.7	Bl,			
083350 X URSAE MAJORIS—						
	3764.7	9.8	Pt.			
084803 S HYDRAE—						
	3764.7	11.2	Pt.			
085005 T HYDRAE—						
	3728.7	8.5	L,	3764.7	7.4	Pt.
085120 T CANCRI—						
	3764.7	7.6	Pt.			
090024 S PYXIDIS—						
	3764.9	8.2	Pt.			
090425 W CANCRI—						
	3729.7	13.6	L.			
091868 RW CARINAE—						
	3707.2	12.5	Bl.			
092551 Y VELAE—						
	3707.2	13.5	Bl.			
092962 R CARINAE—						
	3707.2	8.7	Bl,	3718.0	7.6	Bl.
093014 X HYDRAE—						
	3764.9	12.8	Pt.			
093934 R LEONIS MINORIS—						
	3765.9	11.2	Pt.			
094211 R LEONIS—						
	3755.8	9.6	Cy,	3765.9	8.5	Pt,
	3762.7	9.3	Ms,	3773.7	9.7	Ca.
094622 Y HYDRAE—						
	3765.9	6.4	Pt.			
094953 Z VELAE—						
	3707.2	9.9	Bl.			
095421 V LEONIS—						
	3765.9	13.1	Pt.			
100661 S CARINAE—						
	3707.2	5.0	Bl,	3718.0	5.5	Bl.
101058 Z CARINAE—						
	3707.2	10.3	Bl.			
101153 W VELAE—						
	3707.2	8.5	Bl.			
103212 U HYDRAE—						
	3723.3	5.5	Kd,	3744.3	6.0	Kd,
	3729.3	5.7	Kd,	3748.3	5.9	Kd.
	3737.3	5.9	Kd.			
103769 R URSAE MAJORIS—						
	3756.7	12.0	Kl,	3767.7	12.0	Kl,
	3764.7	12.0	Kl,	3768.5	12.1	Kl,
	3765.9	12.6	Pt,	3772.6	12.0	Kl.
104620 V HYDRAE—						
	3707.3	9.4	Bl,	3765.9	9.5	Pt.
104628 RS HYDRAE—						
	3707.3	11.4	Bl.			
111661 RS CENTAURI—						
	3695.0	8.7	Bl,	3707.3	8.8	Bl,
	3700.9	8.5	Bl,	3717.9	8.2	Bl.
114441 X CENTAURI—						
	3707.3	8.4	Bl.			
115058 W CENTAURI—						
	3695.0	10.1	Bl,	3707.3	11.1	Bl.
	3700.9	10.3	Bl,			
120012 SU VIRGINIS—						
	3769.9	11.9	Pt.			
121418 R CORVI—						
	3769.9	7.0	Pt.			
122001 SS VIRGINIS—						
	3737.3	7.4	Kd,	3744.3	7.4	Kd.
122532 T CANUM VENATICORUM—						
	3769.8	11.6	M,	3769.9	12.4	Pt.
122854 U CENTAURI—						
	3695.0	9.3	Bl,	3707.3	10.6	Bl.
	3700.9	9.4	Bl,			
123160 T URSAE MAJORIS—						
	3750.8	9.5	Sg,	3768.9	10.0	Cy,
	3763.6	10.3	Ca,	3769.8	9.6	M,
	3767.7	9.9	Kl,	3772.6	9.7	Kl.
123307 R VIRGINIS—						
	3768.9	8.0	Pt.			
123459 RS URSAE MAJORIS—						
	3743.5	8.8	Cd,	3768.8	10.9	Ca,
	3746.5	9.2	Ch,	3768.9	10.6	Cy,
	3755.5	9.6	Cd,	3768.9	11.1	Pt,
	3768.5	10.4	Cd,	3768.9	10.4	M.
123961 S URSAE MAJORIS—						
	3743.5	9.8	Cd,	3768.9	9.0	Pt,
	3763.6	9.5	Ca,	3769.8	9.1	M,
	3768.5	8.9	Cd,	3773.7	9.0	Ca.
	3768.9	8.7	Cy,			

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
131283 U OCTANTIS—						
	3695.0	8.6	Bl,	3707.9	8.3	Bl,
	3700.9	8.5	Bl,	3717.9	8.0	Bl.
132422 R HYDRAE—						
	3769.9	7.1	Pt.			
132706 S VIRGINIS—						
	3768.9	12.0	Cy,	3769.9	11.7	Pt.
133155 RV CENTAURI—						
	3695.0	8.0	Bl,	3707.9	8.0	Bl,
	3700.9	7.8	Bl,	3717.9	8.0	Pl.
133633 T CENTAURI—						
	3700.9	6.1	Bl,	3707.9	6.0	Bl.
134236 RT CENTAURI—						
	3700.9	9.3	Bl,	3707.9	9.7	Bl.
134440 R CANUM VEN.—						
	3769.8	8.7	M,	3769.9	8.4	Pt.
134536 RX CENTAURI—						
	3700.9	10.3	Bl,	3707.9	9.6	Bl.
134677 T APODIS—						
	3695.0	13.0	Bl,	3700.9	13.3	Bl.
135908 RR VIRGINIS—						
	3769.9	12.4	Pt.			
140512 Z VIRGINIS—						
	3769.9	12.6	Pt.			
140959 R CENTAURI—						
	3700.9	7.0	Bl,	3717.9	6.7	Bl.
	3707.9	6.8	Bl,			
141567 U URSAE MINORIS—						
	3767.5	9.8	Pt,	3769.8	9.3	M.
141954 S BOOTIS—						
	3768.9	9.4	Pt,	3769.9	8.0	M.
142539 V BOOTIS—						
	3763.9	10.0	Ca,	3768.9	8.8	Pt,
	3768.9	10.2	Cy,	3769.9	10.0	M.
142584 R CAMELOPARDALIS—						
	3757.5	8.7	O,	3763.6	8.2	Ca.
143227 R BOOTIS—						
	3763.9	9.0	Ca,	3768.9	9.5	Pt.
145971 S APODIS—						
	3700.9	9.7	Bl,	3717.9	9.8	Bl.
	3707.9	9.8	Bl,			
151714 S SERPENTIS—						
	3769.9	11.6	Pt.			
151731 S CORONAE BOREALIS—						
	3752.4	6.8	Cd,	3769.9	7.0	Pt.
	3763.9	6.8	Ca,			
151822 RS LIBRAE—						
	3700.9	10.3	Bl,	3707.9	10.4	Bl.
152849 R NORMAE—						
	3700.9	10.3	Bl,	3717.9	8.9	Bl.
	3707.9	9.9	Bl,			
153020 X LIBRAE—						
	3700.9	12.0	Bl.			
153215 W LIBRAE—						
	3700.9	12.5	Bl.			
153378 S URSAE MINORIS—						
	3572.6	8.8	Ym,	3767.7	11.8	Pt.
	3751.5	11.6	Ca,	3768.9	11.4	Cy.
153620 U LIBRAE—						
	3700.9	9.8	Bl.	3707.9	9.4	Bl.
154428 R CORONAE BOREALIS—						
	3562.9	11.0	Ym,	3743.5	6.2	Pt.
	3563.7	11.6	Ym,	3744.5	6.3	Pt,
	3564.7	11.2	Ym,	3748.3	6.1	Kd,
	3565.7	11.2	Ym,	3749.5	6.0	Ly,
	3568.7	[11.1	Ym,	3752.4	6.1	Cd,
	3570.8	[11.4	Ym,	3760.5	6.2	Pt,
	3572.6	11.4	Ym,	3761.5	6.5	Ms.
	3694.3	6.3	An,	3763.9	6.3	Ca.
	3703.3	6.3	An,	3765.9	6.2	Pt.
	3721.9	6.3	Kd,	3765.9	6.3	Cy,
	3726.9	6.2	Kd,	3768.9	6.2	Pt,
	3728.2	6.1	L,	3768.9	6.3	Cy,
	3729.0	6.2	Ch,	3769.9	6.2	Pt.
	3734.6	9.0	Kd,	3769.9	6.3	M,
	3738.9	6.1	Kd,	3772.9	6.2	Pt.
	3743.5	6.0	Ly,			
154536 X CORONAE BOREALIS—						
	3769.9	13.0	Pt.			
154615 R SERPENTIS—						
	3768 9	11.0	Pt.			
154639 V CORONAE BOREALIS—						
	3763.9	7.0	Ca,	3768.9	7.2	Pt.
160021 Z SCORPII—						
	3700.9	10.5	Bl,	3717.9	10.5	Bl,
	3707.9	10.1	Bl,	3723.9	10.6	Bl.
160118 R HERCULIS—						
	3769.9	12.2	Pt.			
160210 U SERPENTIS—						
	3572.6	9.8	Ym,	3769.9	8.0	Pt.
*160221*a X SCORPII—						
	3700.9	10.8	Bl,	3707.9	10.8	Bl.
160519 W SCORPII—						
	3700.9	12.5	Bl,	3707.9	12.1	Bl.
160625a RU HERCULIS—						
	3572.7	10.0	Ym.			
160625b SX HERCULIS—						
	3743.5	8.4	Pt,	3768.9	8.6	Pt,
	3765.9	8.5	Pt,	3772.9	8.7	Pt.
*161122*a R SCORPII—						
	3700.9	11.9	Bl,	3707.9	11.8	Bl.
161138 W CORONAE BOREALIS—						
	3744.5	10.9	Cd,	3769.9	11.8	Pt.
162807 SS HERCULIS—						
	3769.9	10.0	Pt.			
163137 W HERCULIS—						
	3727.0	8.4	Ch,	3763.4	8.3	Ca,
	3731.0	8.2	Ch,	3769.9	8.6	Pt.
	3751.0	8.3	Ch.			
163266 R DRACONIS—						
	3729.0	11.0	Ch,	3768.5	12.0	Pt.
	3757.5	11.8	O,			
164715 S HERCULIS—						
	3727.0	8.5	Ch,	3760.5	9.5	Pt.
164844 RS SCORPII—						
	3700.9	9.8	Bl,	3717.9	10.1	Bl.
	3707.9	9.7	Bl,			
165030 RR SCORPII—						
	3701.0	7.7	Bl,	3717.9	8.6	Bl.
	3707.9	8.3	Bl,			

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
165631 RV HERCULIS—						
	3769.9	10.1	Pt.			
165636 RT SCORPII—						
	3701.0	13.0	Bl.			
170215 R OPHIUCHI—						
	3729.0	8.9	Ch.			
171723 RS HERCULIS—						
	3769.9	12.1	Pt.			
173543 RU SCORPII—						
	3701.0	8.9	Bl,	3717.9	8.8	Bl.
	3707.9	8.7	Bl,			
174135 SV SCORPII—						
	3701.0	11.3	Bl,	3717.9	10.5	Bl.
	3707.9	11.0	Bl,			
174162 W PAVONIS—						
	3701.0	10.1	Bl,	3717.9	11.2	Bl,
	3707.9	10.0	Bl,	3724.0	11.3	Bl.
175519 RY HERCULIS—						
	3729.1	9.4	Ch,	3760.5	9.3	Pt.
	3748.0	9.2	Ch,			
180531 T HERCULIS—						
	3729.1	9.3	Ch,	3750.6	11.5	Sg,
	3742.2	10.9	L,	3751.5	11.8	Ca,
	3744.5	10.7	Cd,	3760.5	11.4	Pt.
	3749.0	11.3	Ch,			
180565 W DRACONIS—						
	3760.5	9.2	Pt.			
180911 NOVA OPHIUCHI #4—						
	3760.5	13.4	Pt.			
181136 W LYRAE—						
	3750.5	11.9	B,	3760.5	12.2	Pt,
182133 RV SAGITTARII—						
	3701.0	13.0	Bl,	3724.0	13.3	Bl.
183308 X OPHIUCHI—						
	3728.3	8.1	L,	3761.5	7.9	Cd,
	3755.4	7.7	Ya,	3763.5	7.7	Ly,
	3756.5	7.9	Ly,	3765.5	7.7	Ly,
	3757.5	7.8	Ly,	3767.5	7.0	Pt.
	3760.5	7.3	Pt,			
184205 R SCUTI—						
	3694.3	5.9	An,	3749.9	6.4	Kd,
	3700.3	5.9	An,	3751.5	6.0	Cy,
	3703.3	5.9	An,	3752.5	6.3	Ya,
	3705.3	5.9	An,	3755.5	6.3	Pt,
	3710.3	5.8	An,	3756.5	6.4	Pt,
	3715.3	5.8	An,	3756.5	6.4	Ly,
	3716.9	5.9	Kd,	3757.5	6.3	Ly,
	3721.9	5.9	Kd,	3760.5	6.6	Ms,
	3722.3	5.9	An,	3760.5	5.9	Pt,
	3726.9	6.0	Kd,	3761.5	6.5	Ms,
	3728.3	5.9	L,	3763 5	5.9	Ly,
	3732.9	6.3	Kd,	3764.5	6.0	Gb,
	3734.9	6.3	Kd,	3765.5	5.9	Ly,
	3736.9	6.3	Kd,	3765.5	6.0	Ms,
	3738.9	6.3	Kd,	3765.5	5.8	Pt,
	3743.5	6.0	Pt,	3768.5	5.9	Pt,
	3743.5	6.4	Cd,	3768.5	5.9	Cd.
	3743.9	6.3	Kd,	3770.5	5.5	Pt,
	3744.5	6.1	Pt,	3771.5	5.5	Pt,
	3745.9	6.4	Kd,	3772.5	5.6	Pt.
	3748.0	6.0	Ch,			
184243 RW LYRAE—						
	3760.5	14.0	Pt.			
184300 NOVA AQUILAE #3—						
	3728.3	10.2	L,	3760.5	10.0	Pt,
	3729.1	9.8	Ch,	3765.5	10.1	Pt,
	3755.5	10.1	Ya,	3768.5	10.0	Pt.
	3755.5	10.1	Pt,			
185032 RX LYRAE—						
	3725.1	11.6	Ch,	3760.5	13.0	Pt.
	3749.0	12.1	Ch,			
185437 S CRUCIS AUS.—						
	3701.0	12.0	Bl,	3724.0	11.9	Bl.
	3707.9	12.0	Bl.			
185537a R CRUCIS AUS.—						
	3701.0	13.3	Bl,	3724.0	13.0	Bl.
	3707.9	13.3	Bl.			
185537b T CRUCIS AUS.—						
	3701.0	13.5	Bl,	3707.9	14.0	Bl.
185735 RT LYRAE—						
	3727.1	10.4	Ch,	3755.5	11.6	O.
	3749.0	10.6	Ch,			
190108 R AQUILAE—						
	3724.6	11.8	Pa,	3733.7	11.6	Pa,
	3725.6	11.4	Pa,	3734.7	10.8	Pa,
	3729.1	11.8	Ch,	3765.5	10.8	Pt,
	3729.7	11.6	Pa,	3767.5	11.0	B.
190818 RX SAGITTARII—						
	3730.1	11.2	Ch.			
190819a RW SAGITTARII—						
	3730.1	10.6	Ch.			
190907 TY AQUILAE—						
	3765.5	10.5	Pt.			
190926 X LYRAE—						
	3755.5	9.0	Pt.			
190933a RS LYRAE—						
	3755.5	13.3	Pt.			
190941 RU LYRAE—						
	3755.5	11.0	Pt,	3765.5	11.1	Pt.
190967a U DRACONIS—						
	3731.0	10.5	Ch,	3755.5	11.0	Pt.
	3749.6	10.9	Hu,			
191017 T SAGITTARII—						
	3730.1	12.0	Ch.			
191019 R SAGITTARII—						
	3730.1	8.5	Ch,	3752.5	7 5	Ya,
	3750.0	7.8	Ch,	3765.5	7.2	Pt.
191033 RY SAGITTARII—						
	3696.0	9.8	Bl,	3733.0	10.5	Ch.
	3701.0	9.9	Bl,			
191331 SW SAGITTARII—						
	3701.0	13.5	Bl.			
191350 TZ CYGNI—						
	3755.6	11 3	Pt.			
191637 U LYRAE—						
	3755.6	10.5	Pt.			
192928 TY CYGNI—						
	3727.1	9.8	Ch,	3755.5	11.2	Gd,
	3749.1	10.5	Ch,	3755.6	10.5	Pt.
193311 RT AQUILAE—						
	3755.6	13.7	Pt.	3762.5	13.2	B.

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
193449 R CYGNI—						
	3726.2	11.1	Ch,	3764.6	11.9	Kl,
	3749.6	10.9	Hu,	3765.5	11.9	Kl,
	3751.7	11.8	Kl,	3767.5	12.0	B,
	3755.5	11.7	O,	3767.5	11.9	Pt,
	3755.6	11.5	Pt,	3767.6	11.9	Kl,
	3761.6	12.0	B,	3772.6	11.9	Kl.
	3761.6	10.8	Ca,			
193509 RV AQUILAE—						
	3765.5	13.0	Pt.			
193732 TT CYGNI—						
	3749.6	6.5	Hu.			
193972 T PAVONIS—						
	3701.0	13.4	Bl,	3724.0	12.8	Bl.
194048 RT CYGNI—						
	3725.2	9.9	Ch,	3761.6	11.1	B,
	3749.6	10.8	Hu,	3763.6	11.9	Sg,
	3750.7	11.5	Sg,	3767.5	11.5	Pt,
	3755.6	11.5	Pt,	3767.6	11.0	B.
194348 TU CYGNI—						
	3725.2	10.3	Ch,	3755.6	11.9	Pt,
	3749.6	11.2	Hu,	3761.6	12.2	B.
194604 X AQUILAE—						
	3756.6	12.2	B,	3765.5	11.8	Pt.
194632 χ CYGNI—						
	3694.3	6.0	An,	3745.9	5.0	Kd,
	3698.4	5.5	An,	3749.0	5.5	Hu,
	3703.3	5.4	An,	3749.9	5.0	Kd,
	3705.3	5.3	An,	3751.5	5.2	Ca,
	3710.3	4.9	An,	3752.6	5.4	Ya,
	3714.3	4.8	An,	3753.3	4.9	An,
	3715.3	4.9	An,	3755.5	5.4	O,
	3716.9	4.9	Kd,	3755.6	5.3	Pt,
	3718.3	4.9	An,	3758.5	5.3	Ca,
	3719.9	4.9	Kd,	3760.5	5.7	Ms,
	3721.3	4.9	An,	3761.5	5.3	Ca,
	3725.1	4.9	Ch,	3761.5	5.8	Ms,
	3726.9	4.9	Kd,	3762.5	5.9	Ms.
	3727.1	4.8	Ch,	3765.4	5.6	Ya,
	3728.9	4.8	Kd,	3765.5	6.1	Ms,
	3730.4	4.9	An,	3765.5	5.4	Pt.
	3732.9	4.8	Kd,	3767.5	5.8	B,
	3734.9	4.9	Kd,	3768.5	5.5	Ca,
	3735.0	4.8	Ch,	3769.5	6.2	Ms.
	3737.9	4.9	Kd,	3770.5	5.6	M,
	3743.9	5.0	Kd,	3771.5	5.5	Ca.
	3743.5	5.3	Pi,	3772.5	6.2	Ms.
	3745.0	4.9	Ch,			
195202 RR AQUILAE—						
	3756.5	12.9	B.			
195308 RS AQUILAE—						
	3743.5	11.4	Ym,	3762.5	11.7	B,
	3748.5	10.7	B,	3765.5	11.8	Pt.
195553 NOVA CYGNI #3—						
	3728.2	10.9	Ch,	3761.5	11.0	B,
	3728.2	11.3	L,	3761.6	11.4	Ca,
	3743.5	11.2	Pt,	3764.5	11.5	Pt,
	3749.5	11.8	Ym,	3765.5	11.0	Ya,
	3755.5	11.0	Pt,	3767.5	11.2	Pt,
	3755.5	10.5	Gd,	3771.5	11.0	Pt.
	3760.5	11.3	Pt,			
195849 Z CYGNI—						
	3728.2	9.5	Ch,	3755.5	10.0	Pt,
	3749.0	9.7	Ch,	3755.5	10.5	Gd.
	3751.5	9.9	B,			
195855 S TELESCOPII—						
	3701.0	12.9	Bl,	3724.0	13.0	Bl
200212 SY AQUILAE—						
	3755.6	12.2	Pt,	3756.5	12.0	B.
200357 S CYGNI—						
	3750.7	12.0	Sg,	3762.6	9.2	Ya,
	3755.6	11.7	Pt,	3763.6	10.5	Sg.
	3756.5	11.1	Bl,			
200514 R CAPRICORNI—						
	3765.5	10.9	Pt.			
200715a S AQUILAE—						
	3730.2	11.0	Ch,	3748.5	10.0	B,
	3743.6	10.3	Pi,	3755.5	9.8	Pt.
	3744.6	10.0	Ym,	3755.6	9.2	Ya.
200715b RW AQUILAE—						
	3748.5	9.2	B,	3755.6	9.1	Ya.
	3755.5	9.1	Pt,			
200747 R TELESCOPII—						
	3701.0	10.8	Bl,	3718.0	9.6	Bl.
	3708.0	10.2	Bl,			
200812 RU AQUILAE—						
	3748.5	9.5	B,	3762.5	9.5	B.
200822 W CAPRICORNI—						
	3701.0	12.2	Bl,	3707.9	12.8	Bl.
200906 Z AQUILAE—						
	3757.5	12.8	B,	3765.5	12.6	B.
200916 R SAGITTAE—						
	3748.5	9.0	B,	3755.6	9.3	Ya.
200938 RS CYGNI—						
	3727.2	7.0	Ch,	3755.5	7.3	Pt,
	3738.2	6.9	Ch,	3755.5	7.8	Gd,
	3744.7	7.3	Sg,	3757.5	7.5	Ly,
	3748.1	6.8	Ch,	3757.7	7.0	Sg,
	3749.5	7.4	Ly,	3761.5	7.5	Ly,
	3752.6	7.5	Ya,	3765.5	7.4	Ly.
	3754.5	7.3	Ly,			
201008 R DELPHINI—						
	3730.2	11.8	Ch,	3755.5	10.3	Pt.
201121 RT CAPRICORNI—						
	3721.9	7.1	Kd,	3749.9	7.3	Kd.
201130 RT SAGITTARII—						
	3701.0	9.2	Bl,	3718.0	7.8	Bl.
	3708.0	8.7	Bl,			
204137b WX CYGNI—						
	3727.2	10.8	Ch,	3757.7	11.0	Sg.
	3744.7	10.6	Sg,	3759.6	11.2	Kl,
	3751.6	10.5	B,	3764.6	11.3	Kl.
	3751.7	11.1	Kl,	3765.5	11.1	Cy,
	3755.5	11.0	Pt,	3767.6	11.2	Kl,
	3755.5	9.6	Gd,	3769.6	11.4	Kl.
	3772.6	11.2	Kl,			
201647 U CYGNI—						
	3750.7	9.6	Ya,	3763.6	9.0	Sg.
	3751.6	8.8	B,	3763.6	9.0	Ca.
	3752.6	9.5	Ya,	3766.3	9.8	Al.
	3755.6	8.5	Pt,	3773.5	9.0	Ca.

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
202240 U MICROSCOPII—				
	3701.0	13.1 Bl,	3724.0	12.8 Bl.
202817 Z DELPHINI—				
	3750.6	8.3 B,	3757.5	8.3 O.
	3755.6	8.5 Pt,		
202946 SZ CYGNI—				
	3742.8	9.2 Pt,	3767.5	9.4 Pt,
	3744.5	9.5 Pt,	3767.6	9.7 B,
	3755.9	9.0 Pt,	3768.5	8.9 Pt,
	3760.5	9.5 Pt,	3770.5	8.8 Pt.
	3764.5	10.0 Pt,	3772.5	8.8 Pt.
202954 ST CYGNI—				
	3741.6	11.0 B,	3755.6	10.0 Pt,
	3748.6	10.2 B,	3768.6	11.0 Hu.
	3751.5	11.0 Gd.		
203226 V VULPECULAE—				
	3743.6	9.5 Ym.	3755.5	8.9 Pt.
203439 R MICROSCOPII—				
	3724.0	11.9 Bl.		
203816 S DELPHINI—				
	3750.6	10.8 B,	3757.5	11.2 O.
	3755.5	11.4 Pt,		
203847 V CYGNI—				
	3725.2	8.5 Ch,	3755.5	8.0 Pt,
	3731.1	8.4 Ch,	3762.6	8.5 Ya,
	3746.2	7.8 Ch,	3763.6	7.8 Ca.
	3750.6	7.5 B,	3773.5	7.6 Ca.
	3751.5	8.9 Gd,		
203905 Y AQUARII—				
	3761.5	12.4 B,	3765.5	12.2 Pt.
204016 T DELPHINI—				
	3727.2	9.6 Ch,	3755.6	10.9 Pt,
	3748.6	10.2 B,	3757.6	10.6 Sg.
204102 V AQUARII—				
	3730.2	8.9 Ch,	3765.5	8.1 Pt.
	3761.5	8.3 B,		
204104 W AQUARII—				
	3728.3	13.7 L.		
204215 U CAPRICORNI—				
	3701.0	11.8 Bl,	3718.0	12.0 Bl.
	3708.0	11.9 Bl,		
204405 T AQUARII—				
	3730.1	11.0 Ch,	3761.4	9.8 Ca,
	3749.1	10.8 Ch,	3761.5	9.7 B,
	3749.6	10.9 Hu,	3765.5	9.4 Pt.
204846 RZ CYGNI—				
	3755.6	11.6 Pt,	3762.6	12.0 Sg,
	3761.6	11.8 B,		
205923 R VULPECULAE—				
	3730.2	8.1 Ch,	3755.5	9.2 Ya,
	3748.6	9.0 B,	3755.6	8.9 Pt,
	3749.6	8.8 Hu,	3762.6	9.4 Pt.
210129 TW CYGNI—				
	3762.6	9.4 B.		
210221 X CAPRICORNI—				
	3701.0	11.4 Bl,	3718.0	10.8 Bl.
	3708.0	10.8 Bl,		
210382 X CEPHEI—				
	3760.8	15.2 Pa.		
210504 RS AQUARII—				
	3715.5	12.0 B.		
210812 R EQUULEI—				
	3755.6	13.4 Pt.		
210868 T CEPHEI—				
	3726.2	10.0 Ch,	3762.5	9.9 B,
	3741.7	10.1 Sg,	3762.6	10.0 An,
	3748.6	9.8 B,	3764.6	10.4 Kl,
	3751.7	10.5 Kl,	3765.6	9.9 An,
	3752.6	10.3 Ya,	3768.7	10.4 Ca.
	3755.6	10.4 Pt,	3769.6	10.7 Kl,
	3756.6	10.4 Kl,	3772.6	10.6 Kl.
	3757.6	10.5 Sg,		
210903 RR AQUARII—				
	3751.5	13.3 B.		
211614 X PEGASI—				
	3749.5	10.3 Gd,	3755.6	10.8 Pt,
	3751.6	10.7 B,	3764.6	10.3 B.
211615 T CAPRICORNI—				
	3701.0	11.7 Bl,	3724.0	12.4 Bl.
	3708.0	12.5 Bl.		
212030 S MICROSCOPII—				
	3701.0	11.3 Bl,	3718.0	10.0 Bl.
	3708.0	10.8 Bl,		
212811 Y CAPRICORNI—				
	3701.0	12.4 Bl,	3724.0	12.4 Bl.
	3708.0	12.3 Bl,		
213244 W CYGNI				
	3703.3	6.4 An,	3730.4	6.5 An,
	3710.3	6.5 An,	3732.6	9.7 Kd,
	3715.3	6.4 An,	3736.9	6.7 Kd,
	3719.9	6.7 Kd,	3743.9	6.5 Kd,
	3726.9	6.7 Kd,	3749.9	6.5 Kd.
213678 S CEPHEI—				
	3732.2	9.6 Ch,	3762.6	8.2 B,
	3748.6	8.4 B,	3768.6	7.9 Hu
	3755.6	7.9 Pt.		
213753 RU CYGNI—				
	3727.2	8.3 Ch,	3755.6	8.5 Pt.
213843 SS CYGNI—				
	3562.9	7.8 Ym,	3760.6	11.1 B,
	3563.7	8.1 Ym,	3760.6	11.7 Sg,
	3564.7	8.0 Ym,	3761.5	10.4 Cd,
	3565.8	8.3 Ym,	3761.5	10.4 Ms,
	3568.7	9.0 Ym,	3761.5	10.8 Ca,
	3570.8	9.4 Ym,	3761.6	10.9 Ly,
	3572.7	9.9 Ym,	3761.6	11.0 B,
	3725.1	11.8 Ch,	3761.6	10.5 Br,
	3726.1	11.8 Ch,	3762.5	10.1 Ms,
	3727.2	11.8 Ch,	3762.6	10.1 B,
	3728.2	11.8 Ch,	3762.6	10.2 Ya,
	3728.2	11.8 L,	3762.6	10.0 Ms,
	3729.2	11.8 Ch,	3762.6	10.0 Sg.
	3730.2	11.7 Ch,	3762.7	10.2 Br,
	3731.1	11.7 Ch,	3763.4	9.7 Cd,
	3732.2	11.6 Ch,	3763.6	9.8 B,
	3733.2	9.5 Ch,	3763.6	10.0 Ca.
	3734.2	8.8 Ch,	3764.5	9.5 Pt.
	3735.2	8.8 Ch,	3764.6	9.8 Kl,
	3736.2	8.8 Ch,	3764.6	9.9 B,
	3738.2	9.2 Ch,	3764.7	9.5 Sg,
	3741.6	11.0 B,	3765.4	9.8 Ya,
	3742.2	11.0 L,	3765.5	9.4 Ms,

VARIABLE STAR OBSERVATIONS, November 20 to December 20, 1923—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
213843 SS CYGNI—Continued.						
	3742.8	11.5	Pt,	3765.5	9.8	Pt,
	3743.5	11.7	Cd,	3765.5	9.4	Gd,
	3743.5	11.6	Pi,	3765.6	9.7	Cy,
	3743.5	11.5	Pt,	3765.9	9.5	Ly,
	3743.6	11.6	Ly,	3765.6	9.7	Kl,
	3743.6	11.7	Ym,	3765.6	9.2	Ca,
	3744.2	11.7	Ch,	3766.3	9.8	Al,
	3744.5	11.7	Pt,	3766.5	9.5	Ms,
	3744.6	11.5	Ym,	3766.6	9.7	Ym,
	3745.6	11.7	B,	3766.6	9.8	B,
	3746.6	11.5	Ym,	3767.5	9.9	Pt,
	3748.6	12.0	B,	3767.6	10.2	B,
	3749.5	11.5	Ym,	3767.6	10.4	Kl,
	3749.6	11.9	Hu,	3768.5	10.5	Pt,
	3750.6	11.6	B,	3768.5	10.0	Ms,
	3750.7	11.5	Sg,	3768.5	10.9	Ly,
	3751.1	11.5	Ch,	3768.5	10.4	Ya,
	3751.5	11.5	Ym,	3768.5	10.7	Ca,
	3751.5	11.9	Gd,	3768.5	10.5	Cd,
	3751.6	11.6	B,	3768.5	10.9	Ym,
	3751.7	11.8	Kl,	3768.6	10.3	Hu,
	3752.5	11.7	Cd,	3768.6	10.2	Ms,
	3752.6	11.5	Ya,	3769.5	[10.9	Ms,
	3752.7	11.8	Sg,	3769.6	11.3	Kl,
	3753.6	11.6	B,	3770.5	12.0	M,
	3754.6	11.5	Br,	3770.5	11.4	Pt,
	3755.5	11.5	Pt,	3770.6	11.4	B,
	3755.5	11.8	Gd,	3771.4	[11.2	Ya,
	3755.5	12.0	O,	3771.5	[10.9	Ms,
	3755.6	11.6	B,	3771.5	11.5	Ca,
	3756.5	11.5	Pt,	3771.5	11.6	Pt,
	3756.6	11.9	Kl,	3772.5	11.7	Pt,
	3758.5	11.7	Cd,	3772.5	[10.9	Ms,
	3759.6	11.1	B,	3772.6	11.6	Kl,
	3759.6	11.5	Kl,	3773.5	11.5	Ca.
	3760.5	11.2	Pt,			
213937 RV CYGNI—						
	3755.6	6.6	Pt,	3768.6	7.2	Hu.
214024 RR PEGASI—						
	3755.6	13.4	Pt.			
214247 R GRUIS—						
	3701.0	8.1	Bl,	3718.0	8.3	Bl.
	3708.0	8.4	Bl,			
215605 Y PEGASI—						
	3751.6	12.4	B,	3764.6	12.9	B.
	3755.6	13.0	Pt,			
215717 U AQUARII—						
	3751.6	11.5	B,	3765.5	11.8	Pt.
215934 RT PEGASI—						
	3748.0	11.0	B,	3761.6	10.9	B.
	3755.6	11.4	B,			
220133b RZ PEGASI—						
	3755.6	9.4	Pt,	3766.6	9.0	B.
	3755.7	9.0	B,			
220714 RS PEGASI—						
	3755.6	11.3	Pt.			
222439 S LACERTAE—						
	3729.2	10.5	Ch,	3762.6	11.1	Ya,
	3751.6	11.4	B,	3764.6	11.9	B
	3755.6	11.2	Pt,			
222867 R INDI—						
	3701.0	12.5	Bl,	3724.0	13.5	Bl.
225120 S AQUARII—						
	3761.5	13.7	B.			
225914 RW PEGASI—						
	3750.8	12.0	Sg,	3756.6	11.6	Pt,
	3755.6	12.0	B,	3766.6	11.0	B.
230110 R PEGASI—						
	3754.6	13.0	Br,	3764.7	13.0	Sg.
	3755.6	13.1	Pt,			
230759 V CASSIOPEIAE—						
	3748.6	9.3	B,	3765.5	8.2	Ya,
	3755.6	8.7	Pt,	3765.7	8.7	Cy,
	3761.6	8.5	B,	3765.7	8.6	Hr,
	3763.7	8.2	Ca,	3768.6	8.5	Hu,
	3764.8	8.5	Sg,	3773.7	8.0	Ca.
231425 W PEGASI—						
	3749.5	8.8	Gd,	3768.6	8.0	Hu.
231508 S PEGASI—						
	3755.6	12.2	B,	3766.6	11.9	B.
	3755.6	12.6	Pt.			
232848 Z ANDROMEDAE—						
	3732.1	9.4	Ch,	3751.6	9.8	Ym,
	3743.5	9.8	Ym,	3755.6	9.6	Pt,
	3746.7	9.9	Ym.	3766.6	9.9	Ym.
	3749.5	10.3	Ym,			
233335 ST ANDROMEDAE—						
	3727.0	8.7	Ch,	3764.8	9.0	Sg,
	3745.6	8.8	B,	3767.6	8.8	B,
	3755.6	8.5	Pt,	3768.6	8.8	Hu.
	3759.6	8.5	B,			
233815 R AQUARII—						
	3703.4	9.0	An,	3761.5	9.1	Ms,
	3722.3	9.0	An,	3761.5	9.0	Ca,
	3728.2	9.1	Ch,	3761.5	9.0	Cd,
	3730.4	8.8	An,	3761.6	9.1	Ly,
	3738.1	9.1	Ch,	3763.5	9.0	Ly,
	3752.5	8.9	Ya,	3765.5	9.1	Ly,
	3753.3	9.1	An,	3765.5	8.9	Ms,
	3755.6	9.0	Pt,	3768.5	8.8	Pt.
	3756.5	9.1	Ly,			
233956 Z CASSIOPEIAE—						
	3767.8	14.4	Pa.			
235053 RR CASSIOPEIAE—						
	3732.2	11.8	Ch,	3761.6	11.6	B.
	3748.6	11.5	B,			
235209 V CETI—						
	3701.0	10.2	Bl,	3718.0	10.9	Bl,
	3708.0	10.3	Bl,	3755.6	13.0	Pt.
235350 R CASSIOPEIAE—						
	3748.6	9.2	B,	3765.7	9.7	Hr,
	3761.6	9.2	B,	3768.8	9.0	Ca.
	3765.6	9.6	Cy.			
235525 Z PEGASI—						
	3697.8	13.0	Pa,	3749.5	10.3	Gd,
	3726.7	11.3	Pa,	3755.6	10.3	Pt,
	3736.6	10.8	Pi,	3772.8	10.1	Pa.
235855 Y CASSIOPEIAE—						
	3767.8	14.2	Pa.			
235939 SV ANDROMEDAE—						
	3755.6	13.2	Pt.			

Total observations: 1504; Stars observed: 316; Observers: 28.

Attention should be called to the fact that Professor Parkhurst's observations of 011208 S Piscium, 032335 R Persei, and 190108 R Aquilae were made with a wedge photometer on the Yerkes 12-inch, and those made by him of 070122a R Geminorum are measures made from photo-visual plates taken with the Yerkes 24-inch reflector.

The following observers contributed to this report: Messrs. Allen "Al", Ancarani "An", Baldwin "Bl", Bouton "B", Brocchi "Br", Carr "Ca", Chandler "Cd", Chandra "Ch", Chisholm "Cm", Cilley "Cy", Fisher "Fi", Gaebler "Gb", Godfrey "Gd", Henry "Hr", Hunter "Hu", Kanda "Kd", Kleis "Kl", Lacchini "L", Mrs. Lytle "Ly", McAteer "M", Mrs. Morris "Ms", Olcott "O", Parkhurst "Pa", Peltier "Pt", Pickering "Pi", Skaggs "Sg", Yalden "Ya", and Yamamoto "Ym".

HOWARD O. EATON, Recording Secretary.

COMET AND ASTEROID NOTES.

D'Arrest-Reid Comet. — In the H.C.O. Bulletin 796, on the basis of observations by Van Biesbroeck at the Yerkes Observatory on December 10, d'Arrest's comet, which was rediscovered by Reid of the Cape of Good Hope on December 1, is described as a faint round nebulosity about 45″ in diameter, with a total magnitude of 13 and a central condensation of magnitude 14.5.

Elements of Reinmuth's Asteroid. — Mr. F. E. Seagrave sends in the following elliptic elements of Reinmuth's asteroid:

Epoch = 1923 November 5.3440 G.M.T.		$\log a$	= 0.377901
M	= 358° 59′ 31″.68	$\log e$	= 9.591184
ω	= 169 25 30″.63	$\log q$	= 0.163155
Ω	= 229 30 07″.73	μ	= 961″.956
i	= 15 52 47″.10	Period	= 3.688 years

COMMUNICATIONS.

The Total Eclipse of the Sun, Sept. 10, 1923.—The accompanying photo gives some idea of the unelaborate but long anticipated preparations that I made to observe the total eclipse of the sun Sept. 10, 1923, at Avalon, Catalina Island, California.

The white sheet in the upper right hand corner was about 10 ft. x 10 ft. and arranged so as to be perpendicular to a line joining it and the sun at time of eclipse. The camera with which this picture was taken was later focused on the sheet in order to attempt to photograph the shadow bands.

The two cameras on the box were bolted to it and then the box was tipped and securely fastened to the ground so that both cameras were pointed at that spot of sky where the sun would be at mid-eclipse. I realized, of course, that since they were not clock driven the cameras would produce a blurred image but I wanted to see how much of a picture I would get regardless of the fact. One camera was equipped with an f 7.7 anastigmat lens and was to be left open during the whole eclipse to see how much of the corona could be photographed. The

other camera was arranged for direct color photography of the chromosphere and prominences. It was fitted with an R.R. lens f 8 and covered with a special ray filter. The plate used was a 3¼ x 4 Lumière Autochrome.

So much for the apparatus. As to the eclipse itself I will now try to give my impressions.

The morning of Sept. 10 dawned with a few clouds in the sky, but indications seemed to be that they would disappear shortly. About 8:30 a. m. our party of three climbed up the hill to a previously selected spot, and, upon arriving, started to set up our cameras At this time the sun was shining brightly through rifts in the clouds. Other people began to come up and with them clouds which seemed to be directly proportioned to the square of the number of people.

As the time for the first contact drew near the sky became quite cloudy and some of the passers by began to leave me such words of cheer as "too bad you are going to have a failure" and "it's all over now." First contact came

Mr. Barnes and his Eclipse Apparatus.

and went unobserved. Although the great majority of the people didn't seem to know or care that it had come I know that there also must have been scattered about in that great throng many who were watching with as expectant eyes as mine. However, most of them seemed to be there to have a good time and not to see an eclipse. One party, in particular, which was near us had by this time settled down to singing "Yes, we have no Bananas," etc., very steadily.

Meanwhile the moon was cutting the sun into an invisible crescent which was rapidly growing smaller but there were only a few who seemed to realize the fact. Then! A rift in the clouds, and, what was more, the sun, shining through a thin mist. Would the clouds continue to go or would they not? Heavy black clouds answered this question.

The critical time was fast approaching. Eight minutes! Seven minutes! Six minutes! Another rift. The sun once more; and again black clouds. Five minutes! Four minutes! Were the mists lowering or did the increasing darkness only make them look hazy? Seconds passed and I waited hoping,—hoping, —hoping that I might see what I had been waiting so long to see.

Suddenly the sky began to grow darker, the people began to grow quieter and a gull made a swift, shadow-like dive into the dark recesses below. I

looked to the northwest, where the hilltops, nearly five miles away were getting alarmingly dark. In the sky over them a huge blue-black cloud was growing thicker and thicker as if some unseen giant was gathering together the folds of an enormous blanket.

I wanted my mother to see the onrushing shadow so I got up to go where she was sitting, not ten feet away, but while I was yet getting up that awe inspiring blanket of darkness was thrown out over us, falling silently and swiftly. For a second I trembled a little. I had a strong desire to crawl down under the rock near where I had been sitting, but I overcame that desire for those precious moments must not be lost. The darkness grew deeper. Then from all over the hills came hushed murmurs of wonder, fear, and amazement. Around the horizon was a faint yellowish glow which soon faded into a blue-grey. I did not watch this long. My eyes were watching for the sun, but no sun came. Seconds slipped by and a brighter glow in the northwest caught my eye. Almost while turning to look, the sky again became filled with light as the great shadow, following its steady course, rapidly receded and vanished into the east.

LELAND S. BARNES.

310 So. Vendome St., Los Angeles, Calif.

A Bright Meteor.—While observing Algol on the night of December 15, I was suddenly startled by the appearance of a most unusual meteor.

About three degrees southeast of ξ^1 Geminorum there appeared an intensely blue star-like light which illuminated the entire sky. For a moment I was temporarily blinded, since the sharp flash seemed to be directly in front of me. Immediately following there appeared a beautiful small white luminous cloud interspersed with tiny gold specks. The cloud slowly floated away to the northeast.

No explosion was heard and no trail was seen, the entire display lasting some five seconds. The time was $8^h\ 32^m$ C.S.T., and the wind blowing from the southwest.

LEWIS E. KLEIS.

Dubuque, Iowa, December 16, 1923.

GENERAL NOTES

Professor A. Fowler, professor of astrophysics, Imperial College of Science and Technology, and Mr. G. I. Taylor, fellow and lecturer in mathematics, Trinity College, Cambridge, have been appointed Yarrow research professors of the Royal Society, under the gift of £100,000 made by Sir Alfred Yarrow. —(*Science*).

Dr. Otto Klotz, director of the Dominion Observatory, Ottawa, Canada, died on December 28, 1923.

Astronomical Lectures at the University of Toronto- Professor C. A. Chant, head of the department of Astronomy at the University of Toronto, sends us the following announcement of a course of lectures to be given by Professor Henry Norris Russell during February.

"On the invitaton of the Board of Governors of the University, Henry Norris

Russell, Ph.D., Professor of Astronomy in Princeton University, will deliver a special course of lectures during the month of February.

"The subject will be 'Applications of Modern Physics to Astronomy.' The course will probably begin on Tuesday, February 12, and will last until the end of the month. The lectures will be given in the Physics Building daily (except on Saturday and Sunday) at 5 p. m. or in the evening.

"Professor Russell is one of the most productive of American astronomers and his numerous researches have brought him world-wide distinction. In addition, he is a lucid and forceful lecturer, and he will present the subject in a simple manner so as to be followed by the amateur as well as the professional scientist.

"Admission will be free and visitors are invited."

The subjects of the lectures will be:

I. The Extent of the Universe.
II. The Sizes and Masses of the Stars.
III. The Analysis of Light.
IV. The Analysis of Stellar Atmospheres.
V. The Constitution and Evolution of the Stars.
VI. The Nebulae.

A Story of d'Arrest.—As the German astronomer d'Arrest is now somewhat in the astronomical mind because of the re-discovery of the comet which bears his name, this may be the moment to recall a story told by Dr. Dreyer in *Copernicus* forty years ago, to the effect that d'Arrest was present with Galle when he (Galle) made the historic first observation of the planet Neptune, and, in fact, it was d'Arrest who first suggested the use of Bremiker's map of the region that was of so much importance, because the other maps available were insufficient. It appears that the map of Hora XXI, the section in question, though it was engraved and printed, had not been distributed at the time, but at d'Arrest's suggestion a proof or advance copy was found in Encke's hall—Encke was then Director of the Berlin Observatory—and possessed of this, Galle soon found the planet, d'Arrest helping. Dr. Dreyer had this direct from the mouth of Professor d'Arrest, and evidently thinks that credit for the actual discovery of Neptune should be given to him as well as to Galle.

D'Arrest was a young man working at the Berlin Observatory at that time, and already had a reputation as a discoverer of comets and computer of orbits. In 1848 he accepted the office of observer at the Leipzig Observatory, and it was there in the year 1851 that he discovered the faint comet that proved to be periodic (6½ years), and has been seen at seven returns. In 1857 he was made Director of the Observatory of the University of Copenhagen, where he did his most important work in observing nebulae and star clusters, for which he received the Gold Medal of the Royal Astronomical Society in 1875.—(H. P. Hollis, *English Mechanics*, December 21, 1923.)

Michigan University Observatory Publications.—Volume III of the *Publications of the Detroit Observatory*, University of Michigan, is a splendid volume, containing 16 papers giving the results of investigations by members of the observatory staff and graduate students in astronomy. It is illustrated with a large number of excellent plates giving beautiful reproductions of the spectra of various stars. Especially interesting are those of the spectra of Nova Geminorum II by R. H. Curtiss and typical stellar spectra by W. Carl Rufus.

The titles of the papers are: Widths of hydrogen and metallic emission lines in class B stellar spectra, by R. H. Curtiss; Studies of class B stellar spectra containing emission lines, sixth paper, by R. H. Curtiss; The spectrum of Kappa Draconis, by R. H. Baker; The spectrum and orbit of Sigma Cygni, by F. Henroteau; Radial velocities of the antapex group of stars, by F. Henroteau; Spectrographic studies of the early Potsdam velocity stars, not known to be binaries, by L. L. Mellor; The spectrum of Alpha Canum Venaticorum, by C. C. Kiess; Some radial velocities of the companion to Alpha Canum Venaticorum, by C. C. Kiess; Spectrographic observations of the variable star RT Aurigæ, by C. C. Kiess; Photographic determination of the positions of stars and nebulous knots in the region of the Great Nebula of Andromeda, by Julia M. Hawkes; Registration of earthquakes at the Detroit Observatory, Ann Arbor, 1916-1921, by W. Carl Rufus; A pictorial study of the spectrum of Nova Geminorum II, by R. H. Curtiss; Some bright line stellar spectra, by R. H. Curtiss; Typical stellar spectra, by W. Carl Rufus; New silicon lines in class B stars, by W. Carl Rufus, R. A. Sawyer and R. F. Paton; The spectrum and radial velocity of comet *f* 1913, (Delavan), by Ralph H. Curtiss and Dean B. McLaughlin.

The Distance of the Star Cluster N.G.C. 6822. — Within the past month our readers may have seen in the daily newspapers an announcement of the discovery of another universe by the observers at Harvard College Observatory. This announcement was probably based on an attempted estimate of the distance of the star cluster N.G.C. 6822 (number 6822 in Dreyer's New General Catalogue of Clusters and Nebulae). This estimate is of course exceedingly uncertain, depending upon the measured diameter of a very faint cluster, the average apparent brightness of its component stars (few if any of its stars appear to be brighter than magnitude 18.5) the assumption that its brightest stars are reddish in color and therefore may be super-giants, of absolute magnitude —3 or —4, and that the angular diameter is inversely proportional to its distance.

The estimated distance of the cluster given by Dr. Shapley in the Harvard Bulletin 796 is of the order of a million light years. If so, N.G.C. 6822 "appears to be a great star cloud that is at least three or four times as far away as the most distant of known globular clusters and probably quite beyond the limits of the galactic system."

Radial Velocities of 125 Stars.—In the *Publications* of the Dominion Astrophysical Observatory, Vol. II, No. 10, Dr. W. E. Harper gives the results of measures of radial velocities of 125 stars, by Dr. R. K. Young and himself. For probably 100 of these stars no previous measures have been published.

New Variable Star in Ara. — A star whose position for 1900 is $16^h\,41^m\,39^s$, $-53°\,28'.3$, has been found, from an examination of its photographic spectrum by Miss Cannon, to be a variable of long period. The spectral class is M0e. The lines Hγ and Hδ are nearly equally bright. An examination of thirty-six photographs, taken during the last thirty-four years, gives the following approximate elements for the variation in light:

$$\text{Maximum} = \text{J.D. } 2413346 + 367^d \cdot E.$$

The range in photographic magnitude is from 12 to [15.

Harvard College Observatory Bulletin 796.

A Decline In Solar Radiation.— In his report for the year 1922-1923 as director of the Smithsonian Astrophysical Observatory Dr. C. G. Abbot speaks of a prolonged decline in the output of solar radiation lasting from November 1921 to September 1922. This was determined from observations made simultaneously, with similar apparatus, at Mount Harqua Hala, Arizona, and Montezuma, Chile, the records at the two widely separated stations showing close accord.

Speaking of the necessity of using instruments of the utmost accuracy, Dr. Abbot says: . . . . "the solar variations rarely exceed 5 per cent, and are mainly less than 2 per cent. It taxes the best observing to reveal them."

The Connection between Sunspots and Solar Radiation.—In the report mentioned above Dr. Abbot states four general principles which appear to be established by the comparison of his radiation results with the daily photographs and spectroheliograms of the sun which he was permitted to examine at the Mount Wilson Observatory.

1. "When increased sun-spot activity appears, either by new spot groups forming on the visible solar disk, by the growth of spots already present, or by the coming on of a new group due to the solar rotation, then on that very day the solar constant value increases.

2. "When a sun-spot group is carried by the solar rotation across the central diameter of the visible disk, then the solar constant value declines, and usually has a minimum on the day following such central transit.

3. "When many spot groups, faculæ, or long strings of dark hydrogen flocculi indicate that great solar activity is prevailing, the solar constant is high.

4. "When a long quiescent period occurs in solar activity, the solar constant values steadily decline."

Energy Spectra of the Stars. — In another part of his report Dr. Abbot says:

"A long and difficult task was undertaken in the observation of the prismatic energy spectra of 10 of the brighter stars in the focus of the 100-inch reflector on Mount Wilson. After much discouragement in preparation of apparatus and preliminary trials, successful results were obtained on three nights. The apparatus included a special bolometer and a special galvanometer. Changes of temperature of about one one-hundred-millionth of a degree centigrade were observable, and electric currents of about 10^{-12} amperes were read with the galvanometer of 10 ohms resistance. So sensitive was the device that it was affected to an almost incredible extent by electro-magnetic induction. It even appeared that the operation of electric power in Pasadena and Los Angeles was effective to cause disturbance through the transmission lines up the mountain, though cut off at the power house a thousand feet away from the telescope. Accordingly, best observations were made after 2 o'clock in the morning."

Eclipses of the Sun is the title of a book, written by Professor S. A. Mitchell and issued recently by the Columbia University Press, which is of very great interest to the professional and the amateur astronomer alike. It is a book which, because of its wealth of scientifically accurate details, will serve as a reference volume for practically any question relating to eclipses. Since it deals with what are unquestionably the most spectacular of astronomical pheno-

mena, the total eclipses of the sun, the book will be read with great pleasure and profit by many who, although they have only a layman's interest in the science of astronomy, are eager to know the circumstances of an event of such rare occurrence.

The frontispiece, a painting of the total eclipse of June 8, 1918, at Baker, Oregon, by Howard Russell Butler, is undoubtedly the finest painting of the corona that has ever been made and is suggestive of the tone of the book as a whole.

The comprehensiveness of the book is indicated by the period of time covered. It begins with the earliest eclipse mentioned in the Chines records, which occurred, according to Oppolzer, on October 22, 2137 B. C., and ends with the latest developments of physical science. Because of the importance of the spectroscope in the study of the sun, a complete account of the development of spectroscopy from 1666, the year in which Newton first noticed the prismatic colors, to its most recent application to the study of the very remote stars through the aid of the 100-inch reflector on Mt. Wilson, is given in two chapters.

Three chapters are devoted to specific eclipses in the observation of which the author had a prominent part. The personal element in the accounts of the eclipse in Sumatra in 1901, in Spain in 1905, and in the United States in 1918, makes these chapters as fascinating as a work of fiction. A careful reading of the chapters on "The Structure of the Atom," "The Importance of Ionization," and "The Einstein Theory of Relativity" will bring one quite well up to date with the topics which are so generally occupying the minds of all scientists of the present day.

It is surprising that so much has been learned in the short time that the sun is in total eclipse. The closing sentence of the introduction emphasizes this point as follows: "The author has traveled more than forty thousand miles to witness four total eclipses of the sun. The total time afforded him for scientific observations during these four eclipses has been a period of less than eleven minutes."

The book is heartily recommended to any who desire to become conversant with ideas in the various fields of science. It contains very few mathematical formulas and hence may be read without difficulty even if one does not have extensive training in mathematics.

The book is composed of twenty-one chapters, a total including the index of 425 pages. It contains 59 illustrations from widely different sources, but all well reproduced and helpful in interpreting the text.

Time and Time Keepers by Willis I. Milham, 600 pp., $6.00 (The Macmillan Company). This book by Prof. Milham of Williams College contains practically everything the general reader on the subject could desire. It gives the history of time keepers from the early sun dials, clepsydras and sand-glasses to the modern watch, chronometer and tower clock. Especial attention is given to the history of American clock and watch making. It tells how time is obtained from the stars and how it is sent out by radio; explains the construction of clocks and watches; describes the different types of escapements and considers the care, repair and accuracy of clocks and watches. The book is profusely illustrated with 339 cuts, most of them half-tones. There is a chapter on famous clocks and watches which is particularly interesting. Among those noted are watches belonging to Cromwell and Milton and clocks at Berne, Rouen, Strassburg and Venice. The book is written in non-technical language and such tech-

nical terms as are used are explained either where used or in a special appendix. It can be recommended for its simplicity of statement and wealth of illustrations. For the serious student of the subject Appendix III on *Museums and Collections* and the Bibliography in Appendix V are of especial value. The latter contains references to about 500 books, pamphlets and special articles.

Prof. Milham has produced a book which deserves a wide distribution.

Relativity, a Systematic Treatment of Einstein's Theory, by J. Rice, M. A., Senior Lecturer in Physics in the University of Liverpool, 392 pages, $6.00. (Longmans, Green & Co.)

The author has succeeded in writing a most interesting book on this most interesting subject. His purpose, as stated in the preface, is to supply a book for the undergraduate student of science in English universities. In order to read it, however, a considerable knowledge of mathematics is required, so that we doubt if it would serve for undergraduate study in the average Amercian university or college. Graduate students, however, who have had the necessary mathematical training, would find it valuable. The author frankly faces the difficulties and seeming paradoxes of the subject. From the way he handles these we believe he must be an interesting teacher as well as an interesting writer.

Correction:—The following is the corrected table in the Abstract—"Some Vagaries of Refraction," by Arthur J. Roy, pp. 21 and 22, January, 1924, number of POPULAR ASTRONOMY:

	To 72°	All
—88°	—0″.23	—0″.12
87	+0.02	+0.13
86	+0.01	+0.11
85	—0.14	—0.05
84	+0.08	+0.15
—83	+0.13	+0.19
82	—0.06	—0.01
81	+0.14	+0.17
80	+0.18	+0.19
79	+0.03	+0.01
—78	—0.03	—0.07
77	+0.06	—0.01
76	—0.25	—0.37
75	—0.19	—0.36
74	—0.08	—0.29
—73	+0.23	—0.04
72	—0.06	—0.38
71	+0.27	—0.14
70	+0.25	—0.24
69	+0.58	+0.01
—68	+0.96	+0.26
67	+0.95	+0.11
66	+1.26	+0.26
65	+1.58	+0.38
64	+1.71	+0.26

Resulting Corrections to P.G.C.

—90°	—0″.01	+0″.04
80	—0.02	+0.18
70	—0.03	+0.28
60	+0.15	+0.53
—55	+0.35	+0.77
50	+0.37	+0.82
45	+0.34	+0.82
40	+0.25	+0.75
—30	+0.14	+0.71
20	+0.05	+0.67
10	—0.03	+0.65
0	—0.04	+0.72
+10	+0.02	+0.87
20	+0.05	+1.04
30	+0.08	+1.27
40	+0.11	+1.74
+50	+0.09	+3.38

Albany Series	Late P. M.	Early Night
#772	0.9963	1.0091
773	0.9976	1.0058
774	1.0046	1.0044

#772 May 11, 1916

10.2 hrs.	0.9961
10.8	0.9978
11.7	1.0081
13.0	1.0100